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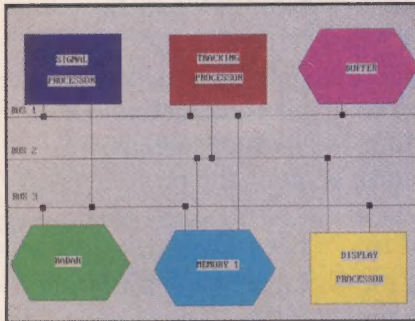
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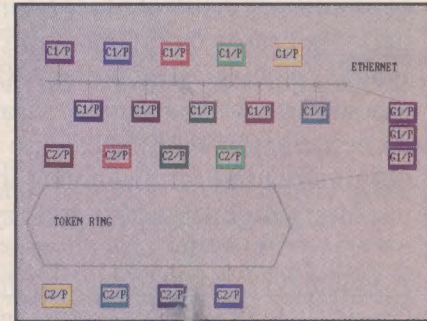
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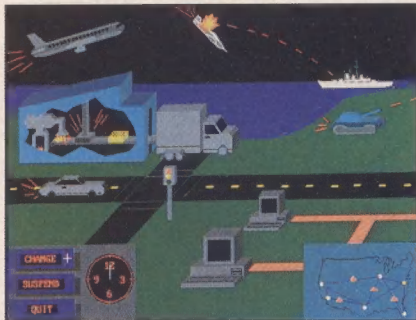
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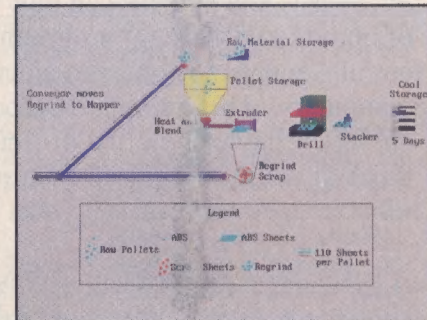
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Spectrum

A state-of-the-art on-line computer graphics projector helps to manage a network of 300 host computers at General Motors' information services subsidiary. Seven Hughes Aircraft Company-built Superprojectors, operating around the clock in the EDS Information Management Center, in Plano, Texas, give more than 100 up-to-date network status reports (operations bulletins, maps) and other network management information. The Superprojectors, connected to display-generating computers, project images with resolutions in excess of 1,000 TV lines into 14x16-foot screens. Originally used for displaying information in military command-and-control centers, the projectors use Hughes-developed liquid crystal light valve technology.

A new navigational aid will help pilots flying the night attack version of the U.S. Navy's and Marine Corps' F/A-18 Hornet aircraft see through smoke, haze, darkness and adverse weather. The main element of the Hornet's night attack system is a forward-looking infrared (FLIR) sensor, called a Thermal Imaging Navigation set (TINS). The TINS, made by Hughes and designated AN/ARR-50, generates a daytime, TV-like image of the dark world ahead of the aircraft and presents this image on an improved "raster" head-up display (HUD). The improved HUD and TINS systems will allow passive low-level navigational and - along with a targeting FLIR - help pilots locate, identify and attack ground targets at night.

PC boards and hybrids can now be electronically trimmed and configured, thanks to a new family of nonvolatile, serially programmable (NSP) integrated circuits developed by Hughes. These NSP circuits enable designers to electronically calibrate PC boards and hybrids with test stations and computers. This automated procedure is a tremendous advantage over mechanical methods, which are less reliable and often difficult to perform. Presently, the new Hughes NSP family consists of nine types of devices. They all feature low-power consumption and redundant circuit techniques to ensure reliable operation and long life.

A specially-equipped van serves as a lab on wheels to test a variety of new automotive sensors. The Hughes-designed mobile testbed, called the Automotive Sensor Instrumentation System, incorporates various sensors, computer-controlled signal conditioning circuits, and monitoring and data-recording equipment. An extensive array of sensors is mounted on a platform attached to the front bumper of the van. A video camera and an infrared camera, also mounted on the front of the van, show what's ahead, while a radar and laser rangefinder provide range and range rate data. Hughes is using the van to study and evaluate various technologies for potential use in advanced automotive sensing systems.

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For more information write to: P.O. Box 45068, Los Angeles, CA 90045-0068

HUGHES

Newslog

MAR 12. **Fujitsu Ltd.**, Tokyo, has acquired a 74.9 percent stake in the products division of **Fulcrum Communications Ltd.** in Birmingham, British Telecom's last domestic manufacturing operation. The sale aids British Telecom's return to its core telecommunication services business and gives Fujitsu an entrée to the European Community's telecommunications equipment market.

MAR 14. **Japan's Government** invited leading computer companies and top research universities to join a 10-year project to develop advanced computers for the next century. Japan added that it would allow foreign participants to hold up to a 50 percent stake in inventions made under the **Sixth Generation Project**.

MAR 14. **GTE Corp.**, Stamford, Conn., completed the US \$6.6 billion takeover of **Contel Corp.**, Atlanta, Ga. The merged company, with a market value of \$28 billion and 197 000 employees, will be the largest U.S. local telephone company and the second-largest mobile cellular communications operator.

MAR 14. **IBM Corp.** and **Microsoft Corp.**, Redmond, Wash., said they are cooperating with a nonpublic inquiry of the **Federal Trade Commission**, Washington, D.C. Microsoft said it believed the cause was a 1989 press release in which the two companies announced plans to hold back on Microsoft's Windows PC operating system and add other features to its OS/2 system. Since then, Microsoft has boosted the capabilities of Windows and downplayed OS/2 in a move at odds with IBM.

MAR 19. The **Senate Commerce Committee** voted overwhelmingly to permit the seven regional Bell companies to design and manufacture telephones and other equipment.

The vote signaled Congress' new interest in seizing oversight of the telecommunications industry from Federal District Judge Harold H. Greene, who oversaw AT&T Co.'s breakup.

MAR 21. **Philips NV** of the Netherlands, and **Matsushita Electric Industrial Co.** and **Sony Corp.** of Japan said over 180 Japanese companies have joined a consortium to promote and develop compact disc-interactive (CD-I), a product that combines sound, pictures, text, graphics, and computer data on a single CD. Similar consortia are to be formed in Europe and the United States.

MAR 22. **Advanced Micro Devices Inc.**, Sunnyvale, Calif., said it would begin volume shipment of its long-awaited Am386 chip, breaking the five-year monopoly held by Santa Clara, Calif.-based **Intel Corp.** with its 80386 chip.

MAR 22. **Thinking Machines Corp.**, Cambridge, Mass., established a new speed record in supercomputing with its Connection Machine-2, which computed 5200 mathematical calculations a second in solving a system of linear equations. In the performance evaluation at the University of Tennessee, Fujitsu Ltd., NEC Corp., and Cray Research Inc. were second, third, and fourth winners.

MAR 26. The Federal Court of the Eastern District of Pennsylvania blocked an attempt by the **Justice Department** to prevent the sale of **Semi-Gas Systems Inc.**, San Jose, Calif., to **Matheson Gas Products Inc.**, Secaucus, N.J., a subsidiary of Nippon Sanso KK, Tokyo. The companies are the world's two leading suppliers of gas distribution and control systems to chip makers.

MAR 26. **IBM Corp.** and **AT&T Co.** said they would develop software that would enable their

competing network management systems to communicate with each other. Companies that use AT&T equipment and IBM computers could then fully integrate the management of their telecom and data networks.

MAR 27. Scientists at **Los Alamos National Laboratory** in New Mexico and a competing group at the **IBM Research Division** in Zurich, Switzerland, said they had discovered microscopic structures in certain superconducting materials that might explain how they transmit electric current with no resistance.

APR 2. Six large computer companies formed the **Open Document Architecture Consortium**, in Brussels, Belgium, to ensure that documents with a mix of text, diagrams, and pictures can be sent worldwide between different types of computers. The six—IBM, Digital Equipment, Unisys, Groupe Bull, Siemens Nixdorf, and ICL—said they will develop facilitatory software by 1993.

APR 2. The **Patent and Trademark Office**, Washington, D.C., opened an inquiry to re-examine the single-chip microcomputer patent obtained last July by **Gilbert P. Hyatt**, La Palma, Calif., after a 20-year debate. **Texas Instruments Inc.**, Dallas, has contended its researcher, **Gary W. Boone**, first invented the device.

APR 3. **Texas Instruments Inc.**, Dallas, and the **Southern California Edison Co.**, Rosemead, said they have developed a way to create solar cells from inexpensive low-purity silicon costing \$1-\$2/kg, rather than much purer silicon costing up to \$75/kg.

APR 4. The **Federation of American Scientists** disclosed that the **Pentagon** is developing a nuclear-reactor-powered rocket to carry heavy

loads above the earth as part of the Strategic Defence Initiative program. The previously secret project, codenamed **Timberwind**, is being assessed by NASA for propelling spacecraft to other planets in less time than conventional rockets.

APR 4. The **Environmental Protection Agency** announced that the **ozone layer** at the latitudes of the United States is thinning at more than twice the rate scientists had expected. The data, showing ozone depletion farther south than had been thought, make necessary a reappraisal on the control of chlorofluorocarbons.

APR 5. The space shuttle **Atlantis** rocketed into orbit on a mission to deploy a \$600 million astronomy satellite, the **Gamma Ray Observatory**, that will look for radiation detectable only beyond the atmosphere.

APR 9. Twenty-one companies announced a new open system standard, the **Advanced Computing Environment (ACE)**, to be based on two computer chips and two operating systems. Led by Compaq Computer, Digital Equipment, Microsoft, MIPS Computer Systems, and the Santa Cruz Operation, the group said it wants to create more sophisticated systems than those now run on desktop computers. ACE will include the Intel x86, MIPS's RISC 4000, Microsoft's OS/2 Version 3.0, and a new version of Unix.

Preview:

MAY 15. The first mapping cycle of the surface of **Venus** is scheduled to be 84 percent completed by the Magellan spacecraft. The Jet Propulsion Laboratory, Pasadena, Calif., said Magellan, using a radar imager to penetrate the planet's thick clouds, has orbited Venus over 1000 times since August.

COORDINATOR: Sally Cahur

IEEE SPECTRUM

SPECTRAL LINES

25 Moving on metric

By DONALD CHRISTIANSEN

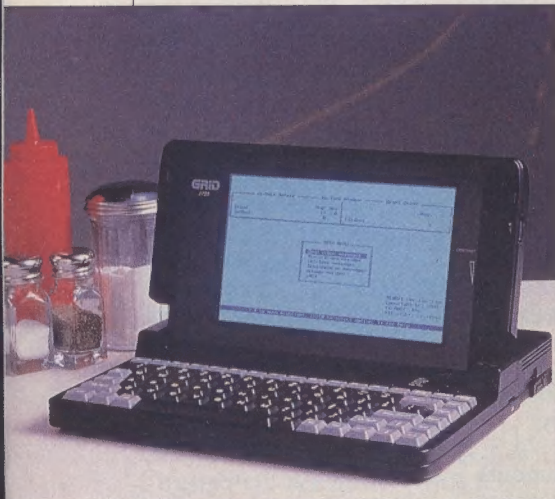
With the aid of Bruce B. Barrow, chairman of the committee that developed the standard on metric practice, *IEEE Spectrum* is embarking on a path that should help speed the electrical engineering community toward comprehension and comfort in applying the SI system.

SYSTEMS

37 A lot in a little

By TRUDY E. BELL

How did engineers maneuver that powerful computer into that tiny box? Today's notebook computers pack motherboard, hard drive, modem,



GRID Systems Corp.

screen, keyboard, and long-lived batteries into a package weighing under 3.6 kg, with lighter successors on the horizon. The secret was heroic engineering of compact components and power management software. Plus, there were problems to overcome that desktop computers never see—including such exotica as rotary shock.

SPECIAL REPORT

26 Smart cars and highways go global

By RONALD K. JURGEN



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Within a 56-km radius of London, Trafficmaster assists motorists on the M25 London Orbital Motorway and interconnecting motorways with real-time information on the speed, direction, and length of any traffic backup, so they can take avoiding action.

FOR THE RECORD

44 The birth of CMOS

By MICHAEL J. RIEZENMAN

Using a microscope and probe tips, Frank Wanlass examines wafers with complementary-MOS transistors he built in the mid-1960s. Patented on Dec. 5, 1967, his invention brought him the 1991 IEEE Solid State Circuits Award in February. The first demonstration circuit, a two-transistor inverter, consumed just a few nanowatts of standby power, six orders of magnitude below the consumption of equivalent bipolar and PMOS gates.



General Microelectronics Inc.

PERSPECTIVE

42 Energy efficiency

By GLENN ZORPETTE

State regulators and utilities across the United States are joining together to make saving electricity as profitable as generating it. Though ignored by the Federal government, the groundswell is unmistakable, being sustained by a growing number of more advanced building techniques and, especially, efficient electrical products—appliances, heating and cooling systems, and other machines. Lighting is a big component;



Lawrence Berkeley Laboratory

in addition to efficient lights, the use of natural light in buildings is being investigated by researchers such as this one at Lawrence Berkeley Laboratory in California.

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Cover: Artist David Schleinkofer portrays smart cars and highways of the future against the background of a computer workstation. See p. 26.

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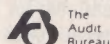
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POSTMASTER: Please send address changes to IEEE Spectrum, c/o Coding Department, IEEE Service Center, Box 1331, Piscataway, N.J. 08855. Second Class postage paid at New York, N.Y., and additional mailing offices.

Printed at 8649 Hacks Cross Rd., Olive Branch, Miss. 38654.

IEEE Spectrum is a member of the Audit Bureau of Circulations, the Magazine Publishers of America, and the Society of National Association Publications.



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Reflections

Engineers: dearth or glut

Ever since I can remember, we engineers have been doing studies about the supply of engineers. Will there be enough of us in the future, we wonder? Invariably our duly constituted committees, panels, and commissions conclude that the country faces the dire prospect of a life-threatening shortage of engineers. In sombre tones of scientific gloom their reports foretell the future—we engineers are becoming an endangered species.

In the halls of government these reports are received with a deeply concerned mood of shock and dismay. "They say there won't be enough of them," says one congressman to another in a hoarse, emotion-laden voice. The other congressman stares fixedly at a blank point in space, his poker expression marred only by a pronounced facial tic. "Does the President know?" he whispers as he glances nervously toward the half-opened door. The only reply is the slightest negative shake of his associate's head. Sensing an impending governmental crisis, the second congressman dares to utter the forbidden question. "When didn't the President know about this engineering shortage?" he asks.

The average citizen is equally concerned. His thoughts hover constantly round the question. How many engineers will be needed in the future? Will there be enough? It is hard to go about everyday life with these eternal questions unanswered. Meanwhile, in response to the authoritative reports on the matter, sales of bumper stickers with the slogan "I brake for engineers" flourish, and committees of citizens struggle with local programs to recycle engineers.

Occasionally I worry about this, too. Should there be more like me, or fewer like me? I am ambivalent. Sometimes I think that it should be manifestly evident that engineering is one of humanity's highest aspirations. What a national tragedy that so few of our youth select this noble profession. The country needs us; the world needs us. The more like us, the better.

On the other hand, we all know of engineers out of work because of cutbacks and layoffs. A vocal segment of our community cries out that there is actually a glut—not

a shortage—of engineers. The fewer of us the better, they say. Then there would be jobs for all, higher salaries, and more respect. The vision of rarity dances before my eyes. I imagine telling someone my occupation at a party and not getting that "another one of those" looks, but instead hearing the person stutter in awe, "A wh... what?"

I wonder, too, about this whole process of determining the future demand for engineers. One method is to take some benchmark period in which times for engineers were good, and to use the number of engineers then as a means of measuring future demand. However it is done, it is hard to avoid making the assumption that there is a certain amount of engineering to do, and engineers will be the ones doing it.



"But I'd rather be a shepherd!"

Such an assumption should work well for forecasting the needs for doctors, for example. You can always count on a certain number of people getting sick, and only doctors are allowed to do the doctoring. This excludes, of course, the possibility of an outbreak of the plague, or—as a doctor once complained to me about conditions in his hometown of San Diego—the outbreak of a health epidemic.

In contrast to the relatively fixed need for doctors, the need for lawyers actually expands with the supply of lawyers. The more you have, the more you need. What a wonderful property!

Not only is the demand for engineers a soft number, but it encompasses a fuzzy set of job descriptions. Which jobs are suitable for engineers and which not? As the demand fluctuates, we dip higher and lower into the

job pool. When I see EEs running hot dog stands, as we did some years ago, then we have certainly gone far too low. If I see lawyers designing VLSI chips, then I will know that we have elevated our talents to the choicest positions. But I won't hold my breath on that.

Now how about the supply of engineers? Strangely, it is fairly predictable. How do a certain number of high school students each year know to choose engineering? The world works in mysterious ways. We may not breed people to portion out to the occupations, as in *Brave New World*, but somehow a relatively constant fraction of students elect to be engineers. At issue is the exact value of that engineering fraction as it drifts slowly from year to year.

Some people say that we should meddle with this fraction, to push it higher or lower, whatever might be our want. We do exercise some control by raising and lowering entrance requirements, but larger variations are harder to implement. The lawyers found a way to increase their fraction with the television show "L. A. Law." Sometimes I imagine a similar show for engineers with, as in the case of "L. A. Law," a slightly sleazy, but incredibly handsome, group of men and women. But instead of dealing with messy divorce cases, our EEs will be engaged in writing fascinating computer programs. It should be a great hit.

Other people say there is no need to meddle with the system. The MARKET will prevail. It is as if there were a bid-and-asked quote for engineers written in the sky. I find it puzzling that high school students who barely know what engineers are have this innate sense of the market forces, but they do.

I suggest we approach this issue of supply and demand in typical engineering fashion. We should develop a mathematical model for the whole macroeconomic system, and run a simulation on a giant supercomputer. The outcome might show that we were short 137 engineers, or some such number, that would have to be recruited or coerced in the grade schools.

So little Johnny comes home from school in tears. "Mommy, they said I have to be an engineer," he blubbers. "Why me, Mommy? Why do I have to be an engineer when Billy gets to be a shepherd?"

His mother looks at him with a firm smile. "Shush, Johnny, they know what's good for you."

We do, don't we?

Robert W. Lucky

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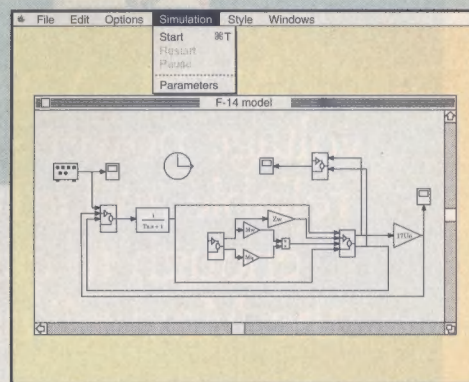
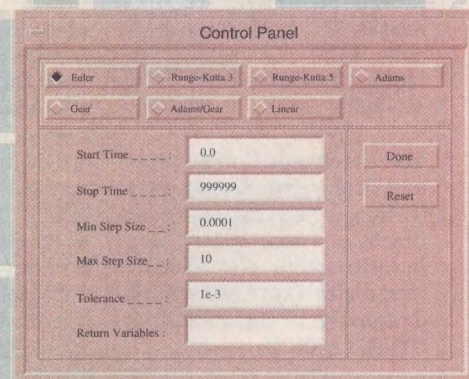
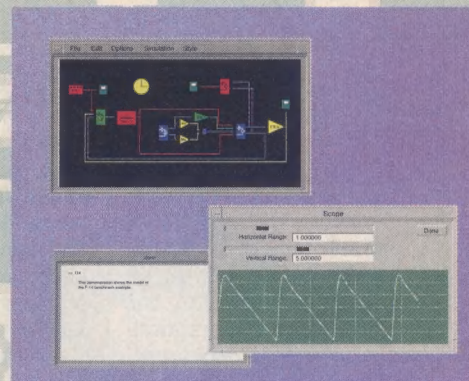
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(Top) Use the Scope block to see the "real-time" response of this F-14 model during the simulation; (Center) Specify simulation parameters via dialog boxes or the MATLAB command line; (Bottom) SIMULAB takes full advantage of the X/Motif and Macintosh windowing systems.

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Meetings, Conferences and Conventions

MAY

Custom Integrated Circuits Conference (ED); May 12-15; Town and Country Hotel, San Diego, California; Laura Morihara, Convention Coordinating, 298 Ohina Place, Kihei, Maui, Hawaii 96753; or Roberta Kaspar, 1597 Ridge Road West, Suite 101C, Rochester, N.Y. 14615; 716-865-7164; fax, 716-865-2639.

41st Electronic Components and Technology Conference (CHMT); May 13-15; Westin Peachtree Plaza, Atlanta, Ga.; Jim Bruerton, c/o KEMET Electronics Corp., Box 5928, Greenville, S.C. 29606; 803-963-6621.

Fifth International Conference on Advanced Computer Technology—Compeuro '91 Reliable Systems and Applications (ED); May 13-16; Palazzo della Cultura e dei Congressi, Bologna, Italy; Sercoop Congressi, Via Crocioli 2, 40100, Bologna, Italy; (39+51) 300 811.

Ideas in Science and Electronics Symposium and Exposition (IEEE Albuquerque et al.); May 14-16; Albuquerque Convention Center, Albuquerque, N.M.; Dave Smoker Communications, 218 Manzano, N.E., Albuquerque, N.M. 87108; 505-266-7292; or Charles E. Christmann, c/o ISE Inc., 8100 Mountain Rd. N.E., Suite 109, Albuquerque, N.M. 87110; 505-262-1023.

Instrumentation and Measurement Technology Conference (IMTC); May 14-16; Omni Hotel at CNN Center, Atlanta, Ga.; Robert Myers, 3685 Motor Ave., Suite 240, Los Angeles, Calif. 90034; 213-287-1463; fax, 213-287-1851.

International Conference on Acoustics, Speech and Signal Processing (SP); May 14-17; Sheraton Centre, Toronto; ICASSP '91, c/o Southex Exhibitions, 1450 Don Mills Rd., Don Mills, Ont., Canada, M3B 2X7; 416-445-6641; fax, 416-442-2207.

34th Midwest Symposium on Circuits and Systems (CAS); May 14-17; Monterey Sheraton Hotel, Monterey, Calif.; Jeff Burl, Code EC/BL,

Naval Postgraduate School, Monterey, Calif. 93943-5000; 408-646-2390.

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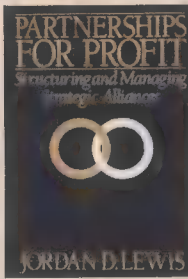
Turning rivals into partners

Norman R. Augustine

The number of alliances among U.S., European, and Japanese firms grew thirtyfold between 1979 and 1985, according to the author of this book. Clearly, global competition has produced global cooperation on a remarkable scale.

The reasons behind this surge are not obscure. It costs a great deal of money to en-

Partnerships for Profit: Structuring and Managing Strategic Alliances. Jordan D. Lewis, Free Press (a division of Macmillan Inc.), New York, 1990, 327 pp., \$27.95.



gage in essential research, develop new products, and break into new markets. Having one or more partners in any of these endeavors spreads the cost, lowers the risk, and avoids duplication of effort.

Japanese companies have practiced this kind of synergy for years, which is one of the secrets of their success. In Japan, even rivals cooperate on long-term research and development, typically with the active support of their Government. The modest relaxation of U.S. antitrust laws that Congress adopted in 1984 gives U.S. companies at least a chance to do the same here.

But in an era when innovation and technical know-how are widely dispersed throughout both developed and developing nations (Malaysia, believe it or not, is now the third largest source of computer chips in the world), no company can afford to overlook what striking new advances may be taking place abroad. Hence the trend toward international partnerships and joint ventures.

Ideally, such an alliance is a "win-win" situation. As an example, Lewis recounts the debut of the compact disc (CD), contrasting it to the painful birth of the videocassette recorder (VCR). Philips NV invented and introduced one model of a home video machine. Sony Corp. developed another, and Matsushita Electric Industrial Co., a third. None could play the other's tapes and the industry had trouble getting off the ground, partly because of this incompatibility.

On the other hand, when Philips developed the CD, it shared its know-how with Sony on condition that Sony accept its product standards. Thus the VHS/Betamax split that impeded the progress of the home video industry was avoided, and everyone gained. Today, Philips has a strong share of the world

CD market and its competitors pay Philips royalties for its technologies.

Of course, not all business alliances are as successful or mutually profitable. Frequently, the partners' values and expectations differ widely, or even run at cross purposes. To illustrate the point, Lewis quotes a U.S. senior manager on his company's partnership with a Japanese firm: "We complement each other well—our distribution capability and their manufacturing skill. I see no reason to invest upstream if we can find a secure source of product. This is a comfortable relationship for us."

Lewis then quotes an executive from the Japanese partner company: "I will feel [bad] if after four years we do not know what our partner knows how to do. We must digest their skills."

Obviously, this business marriage is headed for the rocks—and the ultimate survivor seems clear.

Alliances can be successful only if cultural gaps can be bridged and the interests of both partners equally served. Lewis offers a great deal of useful advice on how to structure different types of alliances to achieve different objectives, and how to avoid or minimize potential conflicts.

The author also includes a chapter on another highly significant type of alliance—that between corporations and universities. In the United States, universities perform about 60 percent of all basic research, and a much smaller—but still vital—proportion of applied research.

My own company, Martin Marietta Corp., maintains partnerships with several major U.S. universities. For example, we are a sustaining partner of the Systems Research Center at the University of Maryland in College Park. The center is a joint government-industry-academia endeavor aimed at maintaining U.S. leadership in vital segments of engineering technology. We feel that technological leadership begins in the classroom and in the laboratory.

Partnerships and joint ventures of all kinds will in all probability proliferate in the years ahead. As Lewis demonstrates, if we choose our partners and define our relationships with care, we can indeed welcome this new era with great confidence and strong expectations of financial success.

Norman R. Augustine is chairman and chief executive officer of Martin Marietta Corp. in Bethesda, Md. He has held several positions in the Office of the Secretary of Defense, including undersecretary of the Army. He is a member of this magazine's editorial board.

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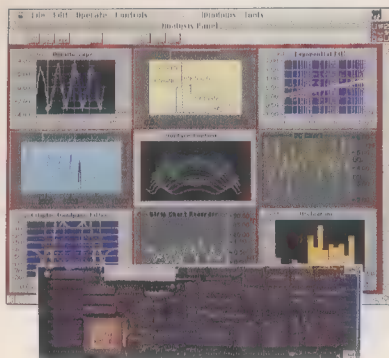
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Legal aspects

Europe 1992: the legal underpinnings

The unification of the European Common Market is likely to leave its mark on technology and its applications in post-1992 Europe. The June 1990 issue of *IEEE Spectrum* looked in-depth at its technical and organizational implications for the engineering community. Additional insights can be gained by examining European Community (EC) proposals, legislation, and rulings on intellectual property and competition policy.

YOURS OR MINE? The intellectual property laws of the members of the EC have long provided incentives for innovation, development, and industrial investment. Despite their benefits, these laws are viewed by the EC as potential obstacles to trade among the member states. The EC has therefore been working to minimize such barriers.

One ongoing effort is devoted to software protection. In 1989, the European Commission, the executive body of the EC, proposed a directive for harmonizing member countries' laws for protecting software. Besides mandating a uniform copyright duration of 50

years from the date of creation of the software, it prescribes legislation to help thwart illegal copying and promote research and investment in computer technology. Also, an authorized user would be allowed to decompile software to the extent required to achieve interoperability.

The EC's policy-making body, the Council of Ministers, approved the directive in principle on Dec. 13, 1990.

CHIP PROTECTION. The EC has taken steps to protect semiconductors as well as software. A directive adopted by the Council in 1986 established uniform protection in the EC for the topographies, or mask works, of integrated circuits. Implemented through laws of the member states, the directive prohibits unauthorized reproduction and commercial exploitation of semiconductors containing proprietary topographies, as well as the unauthorized importation of such products into the EC. The topographies, identifiable by the symbol "T," will be protected generally for 10 years from the date of first commercial exploitation or registration with a member state's agency charged with administering these laws.

Shortly after this directive was adopted, the Council granted interim protection to products from the United States, Japan, and other countries. Last year, protection was extended on a permanent basis to Australia, Austria, Japan, and Sweden, and, until the end of 1992, to Switzerland and the United States.

FURTHERING COMPETITION. In addition to legislating protection for technical advances, the Commission plays an important role in regulating competition among businesses operating within the Common Market. This activity is somewhat akin to the enforcement of the antitrust laws in the United States.

The Commission's power to regulate the marketplace stems from the 1957 Treaty of Rome, which contains several provisions



concerned with competition. One of these, Article 85(1), is of particular interest here. Article 85(1) gives the EC the power to prevent anti-competitive arrangements. It prohibits "all agreements... and concerted practices which may affect trade between Member States and which have as their object or effect the prevention, restriction or distortion of competition within the common market."

From time to time, the Commission is called upon to evaluate a transaction in the light of this provision. A recent decision concerned a joint venture formed to develop and manufacture equipment for Group Spécial Mobile, a proposed pan-European digital cellular telephone system. The partners were AEG AG of Germany, the Dutch/French Alcatel NV, and Oy Nokia AB of Finland.

On July 27, 1990, the Commission granted the enterprise a "negative clearance," stating that the consortium does not violate Article 85(1) because the companies could not have been effective competitors individually given the investment and staffing required, the short time frame mandated by the project, and the financial risk.

BEYOND 1992. By the end of 1992, the EC hopes to have much of the legal and physical infrastructure of a unified market in place. Nevertheless, the process of unification is an evolving one, and therefore will continue as necessary to accommodate new developments and technologies.

Joel Miller is an attorney at the New York City law firm of Weil, Gotshal & Manges.

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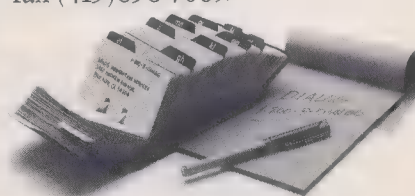
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Technically speaking

HRTV vs. HDTV

A reader asks why high-definition TV (HDTV) is not called *high-resolution TV* since *resolution* is the accepted engineering term for the fineness of detail available in instruments and other electronics.

The International Radio Consultative Committee (CCIR), the standards organization in Geneva, Switzerland, officially adopted HDTV in 1974 as the term for the technology that would double the number of horizontal and vertical lines on a TV screen. Tokyo-based NHK (Nippon Hoso Kyokai—Japan Broadcasting Corp.) had initiated the research in 1970 on what it called high-quality television, according to Toshiya Saito, then with NHK and now manager of the R&D transmission group at Tokyo's Ikegami Tsushinki Co.

When NHK submitted its proposal to the CCIR in 1972, the English term used was *high-definition TV* because, Saito recalled, *high-quality TV* could be taken to refer to the program quality, rather than picture quality. Japanese, British, French, and U.S.

representatives at CCIR meetings debated using *resolution* versus *definition*, but finally settled on *definition* because the French *résolution* means "solution" or "resolve"; it does not have the English word's technical meaning. The French *définition* includes the meaning of the English *definition*, as well as "picture resolution."

Though *resolution* may be more technically precise for the English language, *high definition* has been applied to TV in the United States as early as the 1930s. "For every television development after the mechanical scanning disk, the breakthrough was called high definition," said Joseph Flaherty, senior vice president of technology for CBS in New York City.

Many experts agree *definition* is a better word for the current technology because HDTV encompasses resolution plus color contrast, screen size, smoothness of movement, and sound quality. "*Resolution* is a more objective term, whereas *definition* implies a subjective evaluation," said Walter Ciciora, vice president of technology for American Television & Communications,

Stamford, Conn. "With HDTV, the goal is to please the eye, not instruments."

Indeed, NHK's early research included many investigations into what system gives the most realistic image for human vision. Recently, NHK has begun calling its technology Hi-Vision TV to reflect that emphasis.

Radiation makes more waves

The last Technically Speaking column [March 1991] on the debatable use of *radiation* in connection with the electric and magnetic fields from power lines drew fire from a reader who said power lines do indeed radiate electromagnetic fields.

The issue seems to be a case of theory versus practice. Washington State University electrical engineering professor Robert Olsen told us that theoretically speaking, any system carrying time-varying currents—even an infinitesimally short dipole—emits a propagating field component that can properly be called *radiation*. But this component is minor within a distance equal to one-twentieth of the field's wavelength. In the case of 50–60-Hz fields, with wavelengths in air of 5000 km or more, he said that at the distances of concern for biological effects, the radiating component is so tiny that no known instrument can measure it.

However, the other component, which is quasi-static, is significant near the source; within one-twentieth of a wavelength, it essentially equals the total field. This is the component at issue for biological effects, and, some engineers argue, should not be called *radiation*. For power lines, it drops drastically within a few hundred meters.

The reader also disputed the assertion that electric and magnetic field power lines are independent of one another and should not be lumped as an *electromagnetic field*. According to Olsen, while the electric and magnetic fields from any time-varying source are coupled, in accord with Maxwell's equations, the quasi-static fields are only very weakly coupled. So the fields near power lines behave as if they were independent.

Olsen noted that power engineers have always viewed the electric and magnetic fields from power lines as independent because the electric field can be calculated from the line voltage, while the magnetic field depends only on the load current, which is independent of line voltage. Nonetheless, Olsen said, he sees nothing wrong with referring to the fields as *electromagnetic*.

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For more information, please contact:

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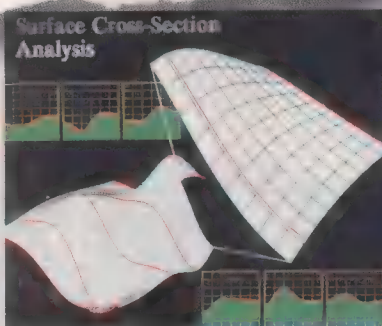


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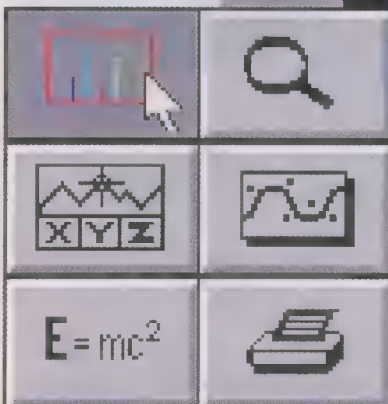
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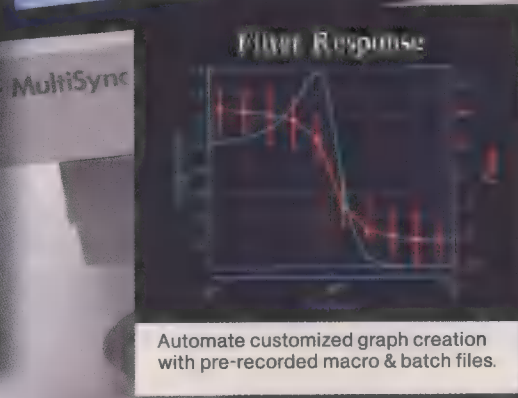
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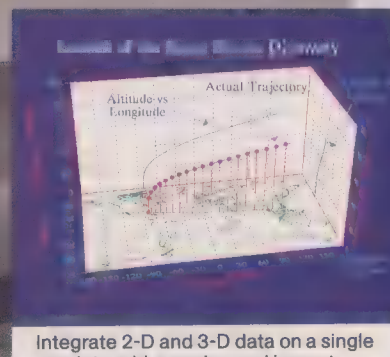
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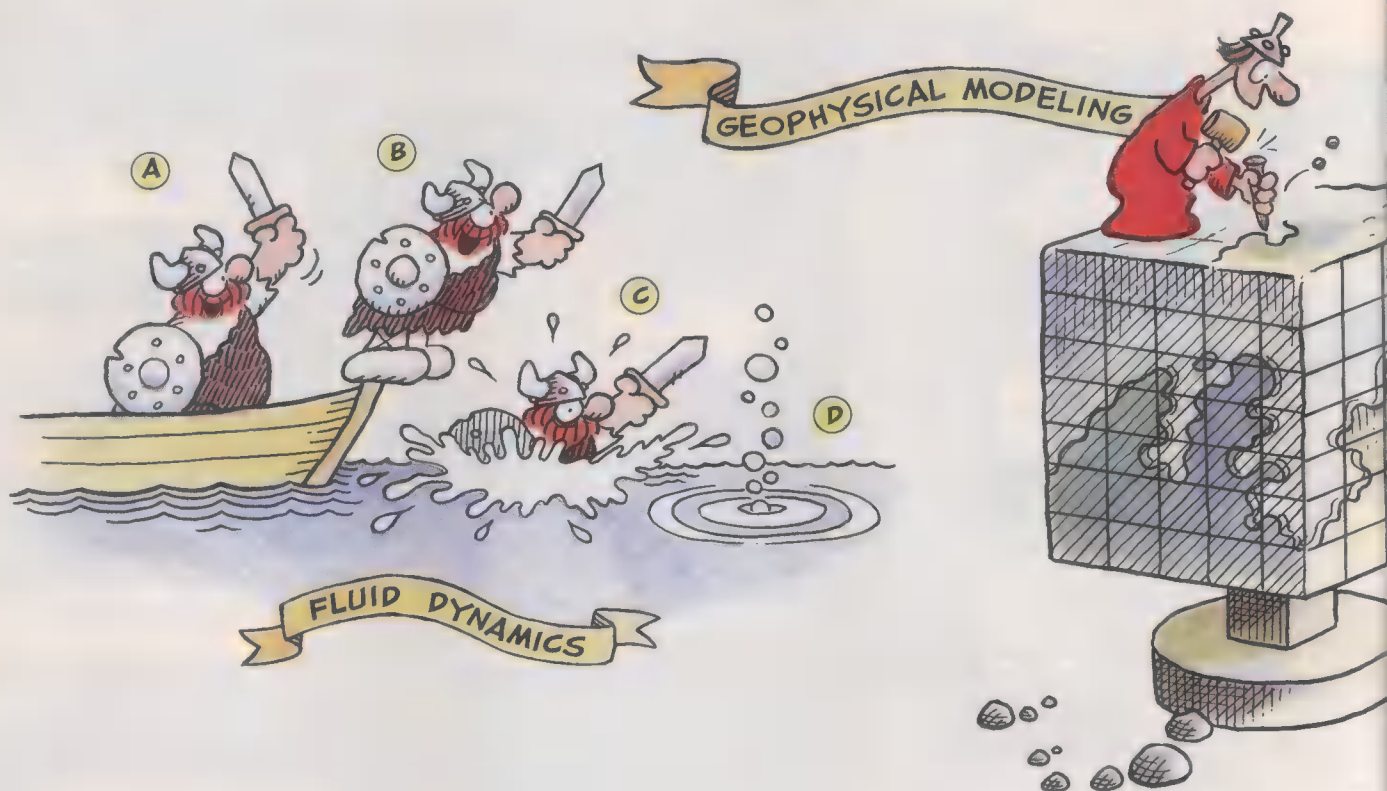
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Vehicular Technology Conference (VT et al.); May 19-22; Sheridan West Port Inns, Maryland Heights, Mo.; Jay Underdown, 58 Judy Dr., St. Charles, Mo. 63301; 314-946-9980 (O); 314-723-4200 (H).

International Semiconductor Manufacturing Science Symposium (ED); May 20-22; San Francisco Airport Hilton Hotel, San Francisco; Corinne Cargnoni, SEMI, 805 E. Middlefield Rd., Mountain View, Calif. 94043; 415-940-6950.

National Aerospace and Electronics Conference—NAECON '91 (AES et al.); May 20-24; Dayton Convention Center, Dayton, Ohio; Sue Brown, ASD/ENES, Wright-Patterson AFB, Ohio 45433-6503; 513-255-6281.

Appliance Industry Conference (IA); May 21-22; University of Wisconsin, Madison; Otto Ehrsam, Bethlehem Steel Co., 701 E. Third St., Bethlehem, Pa. 18016; 215-694-6585.

Annual IEEE/ASME Joint Railroad Conference (IEEE et al.); May 21-23; Sheraton Westport Inn, 191 Westport Plaza, St. Louis, Mo. 63146; Robert B. Fisher, Land Transportation Division, Southeastern Pennsylvania Transportation Authority, 5800 Bustleton Ave., Philadelphia, Pa. 19149; 215-580-4888.

International Symposium on VLSI Technology, Systems, and Applications (ED); May 22-24; Lai Lai Sheraton Hotel, Taipei, Taiwan; Alice Chiang, Lincoln Laboratory, Massachusetts Institute of Technology, 244 Wood St., Lexington, Mass. 02173-0073; 617-981-0711.

Mediterranean Electrotechnical Conference (Region 8); May 22-24; Ljubljana, Yugoslavia; Baldimir Zajc, Fakulteta za Elektrotehniko, Trzaska 25, 61000 Ljubljana, Yugoslavia.

International Workshop on VLSI Process and Device Modeling (ED); May 26-27; Oiso Prince Hotel, Kanagawa, Japan; Hiroshi Iwai, Toshiba Corp., 1 Komukai, Toshiba-cho, Saiwai-ku, Kawasaki 210, Japan; (81+44) 549 2266.

VLSI Technology Symposium (ED); May 28-30; Oiso Prince Hotel, Kanagawa, Japan; Dirk Bartelink, Hewlett-Packard Co., 3500 Deer Creek Rd., Palo Alto, Calif. 94304; 415-857-5364.

35th International Symposium on Electron, Ion and Photon Beams (ED); May 28-31; Seattle Sheraton Hotel and Towers, Washington; Jane Shaw, IBM Corp., Thomas J. Watson Research Center, Room 17-259, Yorktown Heights, N.Y. 10598; 914-945-2528.

Conference on Computers, Power and Communications in a Rural Environment—Wescanex '91 (Region 7 et al.); May 29-30; Delta Regina Hotel, Regina, Sask., Canada; Bill Kennedy, Saskatchewan Power Corp., 2025 Victoria Ave., Regina, Sask., Canada S4P 0S1; 306-566-2106.

45th Annual Symposium on Frequency Control (UFFC); May 29-31; Marriott (Continued on p. 14H)

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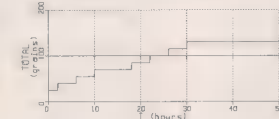
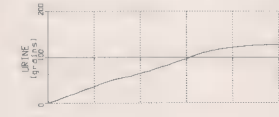
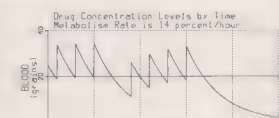
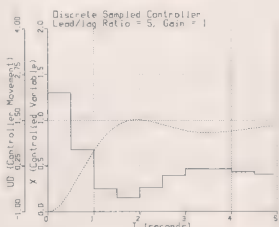
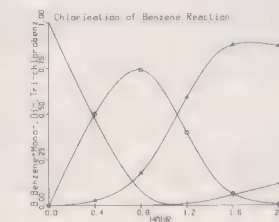
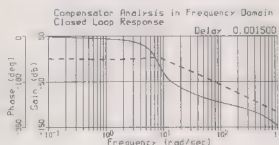
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HIT THE GROUND RUNNING

Calendar

(Continued from p. 14D)

Los Angeles Airport, Los Angeles; Raymond L. Filler, U.S. Army Electronics and Technical Devices Laboratory, SLCET-EQ, Fort Monmouth, N.J. 07703; 908-544-2467.

JUNE

Fourth International Conference on Industrial and Engineering Applications of Artificial Intelligence and Expert Systems (COMP et al.); June 2-5; Waiohai Hotel, Kauai, Hawaii; Moonis Ali, University of Tennessee Space Institute, MS15, B.H. Goethert Parkway, Tullahoma, Tenn. 37388; 615-455-0631, ext. 236; fax, 615-454-2354.

18th IEEE International Conference on Plasma Science (IEEE/NPS); June 3-5; Wyndham Williamsburg Hotel, Williamsburg, Va.; Karl H. Schoenbach, Physical Electronics Research Institute, Old Dominion University, Norfolk, Va. 23529-0246; 804-683-3741.

Intensive Course on Electrical Contacts (IEEE/CHMT); June 3-7; Radisson

Plaza Raleigh, Raleigh, N.C.; IEEE Holm Conference Registrar, 445 Hoes Lane, Box 1331, Piscataway, N.J. 08855-1331; 908-562-3863; fax, 908-562-1571.

Pulp and Paper Industry Conference (IA); June 3-7; Hotel des Gouverneurs Le Grand, Montreal; Michel Riverin, Relcon Inc., 0403 Clement St., Montreal, Que., Canada H8R 4B4; 514-595-5999; fax, 514-595-5680.

International Conference on Consumer Electronics (IEEE et al.); June 5-7 (Educational Session, June 4); Westin Hotel O'Hare, Rosemont, Ill.; Diane D. Williams, 67 Raspberry Patch Dr., Rochester, N.Y. 14612; 776-865-2938.

Workshop on Variable Structure Control of Power Conversion Systems (CS); June 6; Hotel Flamingo Hilton, Reno, Nev.; Andrzej Trzynadlowski, Electrical Engineering Department, University of Nevada, Reno, Nev. 89557-0030; 702-784-1490.

Microwave and Millimeter-Wave Monolithic Circuits Symposium (ED); June 9-10; Hynes Convention Center, Boston; Charles Huang, Anadigics Inc., 35 Technology Dr., Warren, N.J. 07060; 201-668-5000.

VLSI Multilevel Interconnection Conference (VMIC) (ED); June 10-13; Santa Clara Marriott Hotel, Santa Clara, Calif.; Thomas Wade, Engineering Dean's Office, University of South Florida, 4202 Fowler Ave., Tampa, Fla. 33620; 813-974-3786.

International Microwave Symposium-MTT '91 (MTT); June 11-13; Hynes Convention Center, Boston; Peter Staecker, MA-COM, M/S 704, 52 South Ave., Burlington, Mass. 01803; 617-272-3000, ext. 1602.

Second International Workshop on Rapid System Prototyping (C); June 11-13; Sheraton Imperial Hotel, Research Triangle Park, N. C.; Ken Anderson, Siemens Corporate Research, 755 College Rd. East, Princeton, N.J. 08540; 609-734-6550; fax, 609-734-6565.

Ninth Biennial University/Government/Industry Microelectronics Symposium (ED); June 12-14; Melbourne Holiday Inn Oceanfront, Melbourne, Fla.; Darlene Kirschner, Florida Institute of Technology, 150 W. University Blvd., Melbourne, Fla. 32901; 407-768-8000, ext. 8763.

Second International Conference on
(Continued on p. 14J)

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Circle No. 33



Calendar

(Continued from p. 14H)

Magnetic Recording Systems (MAG et al.); June 12-15; Hidden Valley Retreat, Pittsburgh; Gordon Hughes, Seagate Technology, 900 Disc Dr., Scotts Valley, Calif. 95066; 408-439-2626; fax, 408-438-4190.

Device Research Conference (ED); June 16-19; University of Colorado, Boulder; Larry Coldren, University of California, Department of Electrical Engineering and Computer Engineering, Santa Barbara, Calif. 93106; 805-893-4486.

Eighth IEEE Pulsed Power Conference (ED); June 17-19; Sheraton Island Harbor Hotel, San Diego, Calif.; Roger White, Maxwell Laboratories Inc., 8888 Balboa Ave., San Diego, Calif. 92123; 619-576-7884.

Joint Magnetism and Magnetic Materials—Intermag Conference (MAG); June 18-21; Pittsburgh Hilton, Pittsburgh; Diane Suiters, Conference Coordinator, 655 15th St., N.W., Suite 300, Washington, D.C. 20005; 202-639-5088; fax, 202-347-6109.

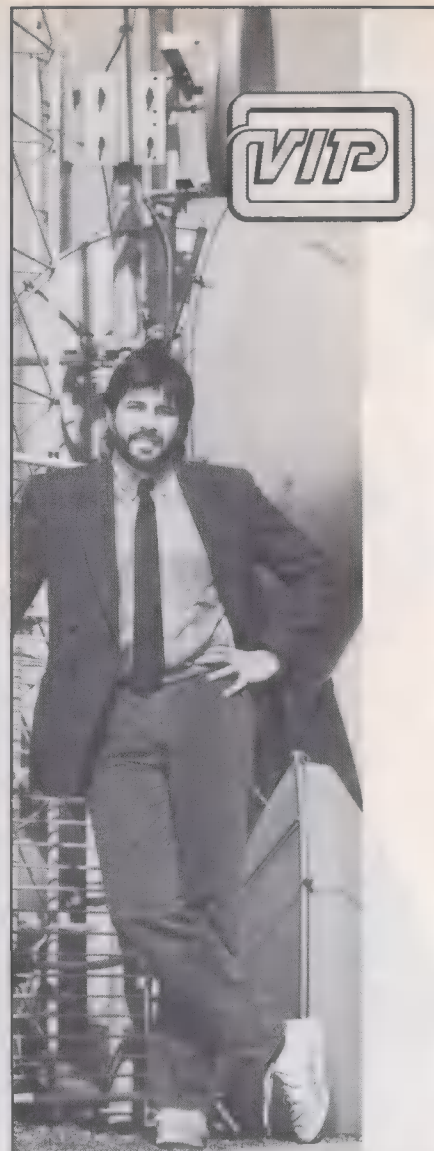
SSIT Interdisciplinary Conference (SSIT); June 21-22; Ryerson Polytechnical Institute, Toronto; Diane Falkner, Program Director Conferences, Ryerson Polytechnical Institute, 350 Victoria St., Toronto, Ont., Canada M5B 2K3; 416-979-5184; fax, 416-979-5148.

International Conference on Communications (COMP); June 23-26; Denver Technical Center, Hyatt and Sheraton, Denver, Colo.; Russell Johnson, Western Telecommunications Inc., 4643 S. Ulster St., Suite 400, Denver, Colo. 80237; 303-721-5650.

Antennas and Propagation Society International Symposium and URSI National Radio Science Meeting (AP); June 23-27; University of Western Ontario, London, Ont., Canada; A. R. Webster, Faculty of Engineering Science, University of Western Ontario, London, Ont. N6A 5B9, Canada; 519-679-6294.

International Symposium on Information Theory (IT); June 23-28; Budapest Conference Center, Budapest, Hungary; Anthony Ephremides, Department of Electrical Engineering, University of Maryland, College Park, Md. 20742; 301-405-3641.

Compass '91 Computer Assurance Conference (AES); June 24-27; National Institute of Standards and Technology, Gaithersburg, Md.; Andrew Moore, Naval Research Laboratory, Code 5542, Washington, D.C. 20375; 202-767-6698.



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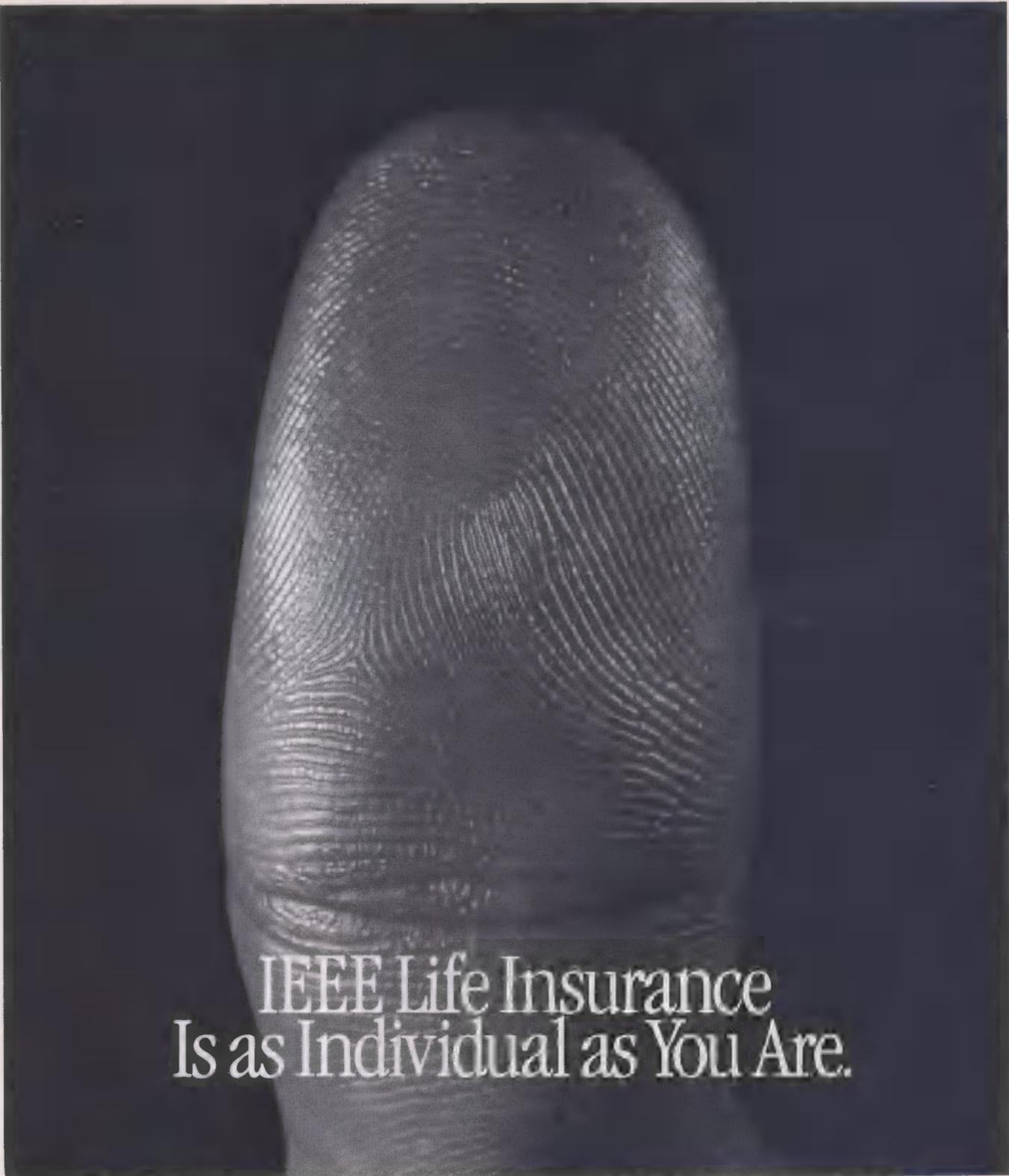
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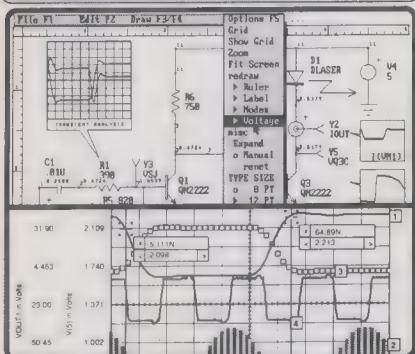
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Whatever happened to...?

Home banking

1985 Banks, their competitors, and their customers are coming to realize that the age of banking will usher in a different environment, in which money flows at the speed of light...

Patrick Frazer
 Plastic and Electronic Money

During the late 1970s and early 1980s, the world was caught up in the grip of the home computer revolution. One industry that was particularly enthusiastic about the potential of personal computers was banking. The possibility of offering banking and financial services from the home appealed to many as a way of expanding their offerings and winning new customers, and they jumped quickly to exploit the new technology.

But the industry soon learned that technology alone does not necessarily make a successful product; consumer interest waned and the business fell short of expectations. It is only after more than 10 years of trying that home banking may finally be accepted.

The first interactive banking service was started in 1979 in Great Britain by the Nottingham Building Society working with British Prestel and the Bank of Scotland. The Homelink Service was an interactive videotex system that used modified television sets to display information transmitted over telephone lines. Users could obtain account balances, transfer funds between accounts, and make payments to organizations that had accounts with the Bank of Scotland. Adapters for the linkup were available for £100 (about US \$212) or loaned free to subscribers with £4000 in their accounts.

The service grew slowly but steadily, with thousands of accounts by early 1984. Similar experiments began soon after in Great Britain and other countries. Bildschirmtext, offered by West Germany's Verbraucherbank, supplied a wide variety of services and was one of the fastest growing, with over 2000 terminals installed at the end of 1981. Similar projects launched in Japan through Nippon Telegraph & Telephone Corp. and in France through Crédit Commercial de France in the early 1980s also attracted consumer interest.

The first home banking service in the United States was the Pronto System offered by Chemical Bank in New York City. Designed for access from a home computer, it provided strictly financial services. Joint ventures offering home shopping as well as banking services involved such companies as Bank of America, Chemical Bank, AT&T, and Time Inc. By 1985 there were 58 000

home banking subscribers in the United States, according to *American Banker*.

Over time, however, the early enthusiasm for home banking began ebbing as problems became apparent. First, most banks were limited to interacting with large corporations set up for electronic funds transfer (EFT) transactions. Customers had to go through the bill-paying process twice: once electronically for institutions on the service, and again manually for smaller companies. Another problem was cost. Most users rented dedicated videotex terminals that communicated over phone or cable television lines.

In the United States in 1986 alone, three major home banking services involving Bank of America, AT&T, Time Inc., and Knight-Ridder Newspapers, among others, lost over \$130 million when they closed down. Similar write-offs occurred around the world, and by 1988 most of the banks and financial services had abandoned their offerings.

Recently, though, a small but receptive new market for such services has emerged. Because of the availability of inexpensive home computers and modems, banks no longer have to invest large sums in customized equipment.

Chase Manhattan Bank in New York City will not disclose the number of its home banking customers but admits that such services are paying for themselves.

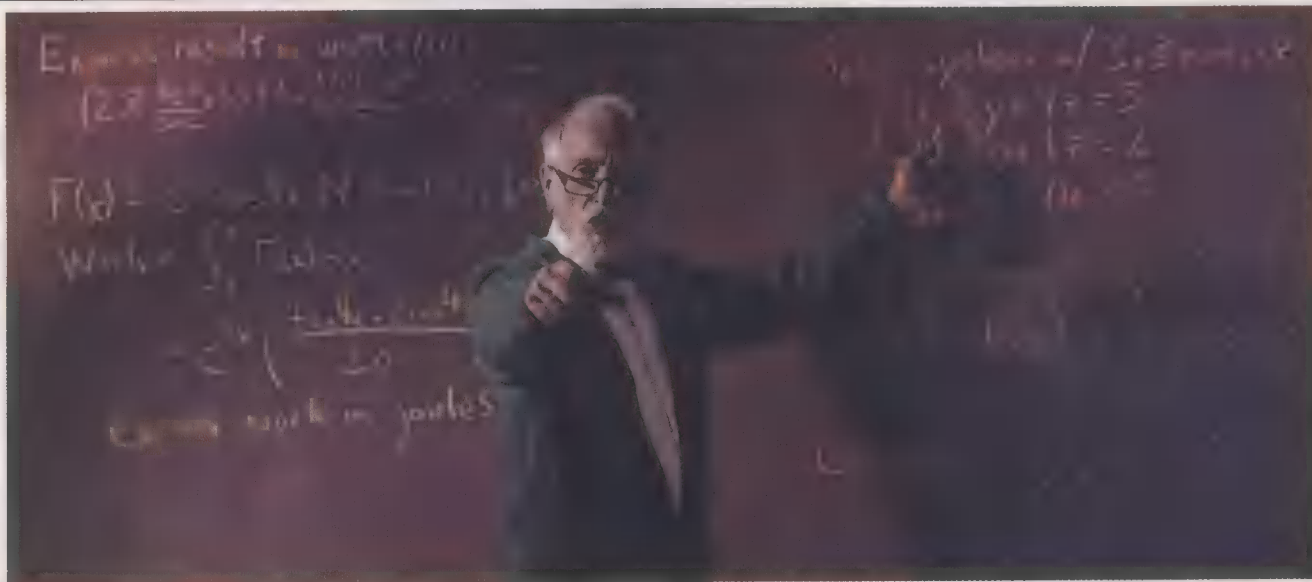
Other banks are opting to use established computer service networks as the vehicle for their services. Bank One of Columbus, Ohio, has just contracted to offer home banking through the Prodigy Service from IBM Corp. and Sears Roebuck & Co.

One of the most successful electronic bill payment ventures has been CheckFree, offered by CheckFree Corp. of Columbus, Ohio. CheckFree allows the user to credit any financial institution or individual, either directly by an EFT network or by laser-printing a paper check and mailing it to the creditor; many bank-based services do not offer this capability. The service costs \$9.95 per month, for up to 20 transactions, and \$3 per 10 transactions thereafter, about the cost of envelopes and postage.

Several other firms are offering advanced financial management and bill payment software that can interface with CheckFree. Quicken, from Intuit Inc., of Menlo Park, Calif., and Andrew Tobias's Managing Your Money, from MECA Ventures Inc., Westport, Conn., allow users to track stocks and credit cards and to generate reports on monthly budgets, taxes, and cash flow.

COORDINATOR: Kevin L. Self
 CONSULTANTS: Ken Mills, Chase Manhattan Bank;
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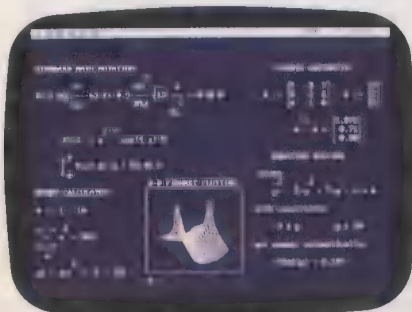
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Forum

Of teachers, engineers, and creativity

I was disturbed by two statements made by Walter Frey ["Schools miss out on dyslexic engineers," December, p. 6]. They single out non-U.S. graduate teaching assistants as a major cause of declining standards in U.S. colleges.

I have enjoyed the benefits of the U.S. higher education system for several years now, having studied under the tutelage of U.S.-born full professors and non-U.S.-born teaching assistants. I have learned that a particular national origin does not a good teacher make. Some U.S.-born professors are atrocious, and some non-U.S.-born assistants are superb. Generally, full professors are more interested in their pet research projects than in their lectures. Tenured professors can also afford to be lazy, while non-U.S.-born teaching assistants have to be careful about the grades they get from student evaluations.

Frey implied that non-U.S.-born teaching assistants do not have enough knowledge to fulfill their teaching obligations. To the best of my knowledge, assistantships are awarded competitively on the basis of academic merit. Keep in mind that most non-U.S.-born teaching assistants are the product of exceptional primary education systems—hence, they have that rare blend of discipline, industriousness, and academic background that allows them to shine even in hostile environments.

Full professors are made, not born. The necessary training has got to start somewhere. Today's assistant may be tomorrow's professor. This brings us to another interesting observation. By the turn of the century, the majority of full professors will be of non-U.S. origin.

We then come to the economic aspect of Frey's ideas. Some full professors are paid more than 10 times as much as teaching assistants are. If every three teaching assistants are replaced by a full professor, this could mean that tuition would be doubled. How many U.S. students would be able to afford a college education? Moreover, where would the U.S.-born professors to fill these positions be found?

In fact, the main reason that non-U.S. students are awarded assistantships is that there are not enough qualified U.S.-born students to fill these positions.

As members of an "elite" but voiceless minority, non-U.S.-born teaching assistants make excellent scapegoats. Please do not lay the blame for the ills of the U.S. education

system on them. The problem lies with the "all-American" kid when he enters college. This kid is the product of a broken family, a dismal primary education system, and the idiot box. The kid speaks fluent American English, but does not have reading, writing, or arithmetic skills. Do you expect miracles in college?

I can come to only one conclusion—the problem Frey has with teaching assistants is that they are foreign born. Seems like he suffers from a mild form of dyslexia and an acute case of xenophobia.

Johns Daniel
Dayton, Ohio

The author responds:

Reader Daniel has misread my article. It was not about declining standards in U.S. colleges; it dealt with problems faced by dyslexic engineers in navigating the educational system in the United States. The sentence to which Daniel addresses his objection was: "Colleges must also stop using foreign-born teaching assistants *speaking poor English* [italics added] and bring full professors and their knowledge into the classroom." I said nothing about non-U.S. graduate teaching assistants being a major cause of declining standards in U.S. colleges.

I was impressed by Walter Frey's *Speakout*. I do not believe I have ever read an article that covered its subject as well as this one.

His approach to the subjects of creativity and innovation in some engineers and the lack of the same in others helps me to understand why there is this difference. But I do not understand why the noncreative types want to work in a field that calls for them to be creative. I can guess that the answer is that "they like to eat."

I have known creative engineers but do not remember any of them being dyslexic. However, I would classify most of my fellow engineers as noncreative. They typically want to do the next project in such a way that they can point to a previous project as a precedent. They fear the critic who asks, "Who ever heard of doing it that way?" Many of these engineers were educated outside the United States.

I had always thought that engineers, by necessity, had to be rich in imagination. After all, if one starts off with nothing except a blank piece of paper, doesn't it require some imagination to get an idea started? Yet some have trouble beginning a project until a well-defined path is laid out for them.

I believe Frey's assertion that engineers educated before 1960 were and are generally more creative than those educated later

is correct. This fact is generally hidden by ascribing the innovative ideas of those older engineers to their experience rather than their creativity.

Having said this, I recently heard of a 1980s-educated high school mathematics teacher who is also an artist and is very creative. This teacher's students constantly exclaim, "Who ever heard of a math teacher who also paints pictures!" So some creative people are still managing to get through the left-brained barriers. But, as Frey recommends, we should modify our educational methods to recognize that there are bright people who are stamped with a different form of intelligence than the one we measure in our schools. We should extend to them an appraisal of their abilities equal to that we now extend to their left-brained peers.

Norman R. Paul
Springfield, Pa.

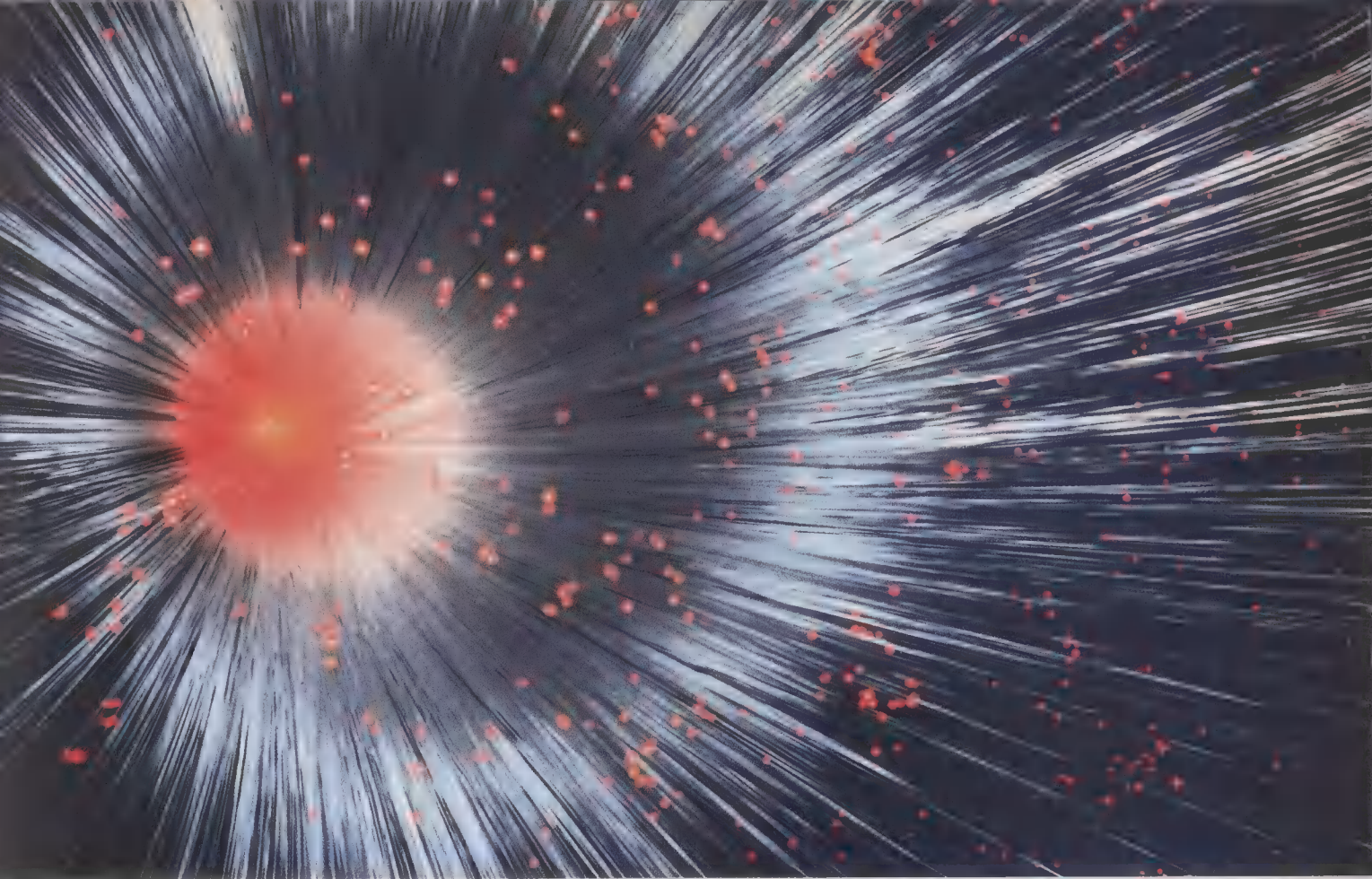
Corrections

On p. 18 of the March issue, 100 kilowatts over seven years should have been equated with 22 terajoules. On p. 35, 2 cents per kilowatthour should have been given as about half a cent per megajoule.

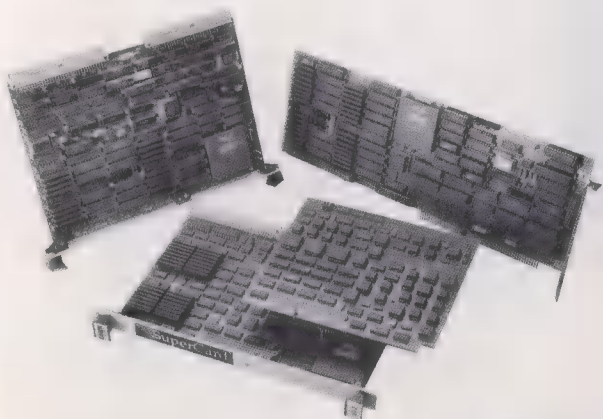
On p. 53 of the April issue, the table should have included the SuperCard family of i860 vector processor boards from CSPI, Billerica, Mass. Compatible with the VMEbus, ATbus, SBus, and Turbochannel platforms for hosts made by Sun, Hewlett-Packard, Motorola, Compaq Computer, and Digital Equipment, the family has a performance range of 80 MFlops to 1.5 GFlops. Contact: In the United States, 1-800-325-3110; worldwide, 617-272-60210; fax, 508-663-0150; or write to CSPI, 450 Linnell Circle, Billerica, Mass. 01821.

On p. 90 of the issue, the last paragraph of the *Power in hand* item should have read as follows: The 100G Power Visa is available in the United States at an introductory price of \$3295 and will be available overseas in July. Contact: Basic Measuring Instruments, 335 Lakeside Dr., Foster City, Calif. 94404-1147; 415-570-5335. —Ed.

Readers are invited to comment in this department on material previously published in *IEEE Spectrum*; on the policies and operations of the IEEE; and on technical, economic, or social matters of interest to the electrical and electronics engineering profession. Short, concise letters are preferred. The Editor reserves the right to limit debate on controversial issues. Contact Forum, *IEEE Spectrum*, 345 East 47th Street, New York, N.Y. 10017 U.S.A.



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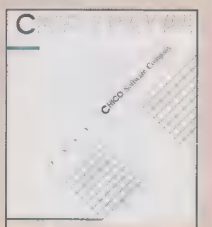
Software reviews

Solving equations by computer

By Kenneth R. Foster

Chico Solver is a user-friendly program that is designed to help engineers and scientists solve equations by computer. With a simple text editor, the user enters equations to be

Chico Solver. Chico Software. Equation-solving software for the IBM PC/AT or compatible with MS-DOS 3.1 or later; 512K of available memory; \$299.



solved. The problems can include systems of algebraic equations, systems of multiple Nth order differential equations, and those having multiple integrals and iterated summations, among other things.

The package's main selling point is its user-friendliness. Commands are entered by using pop-up menus and function keys that are described on the screen. Chico Solver comes with a 125-page, well-written man-

ual and several example files. I quickly became comfortable with the program, and was able to do useful work with it almost immediately.

One innovative feature allows the user to directly enter a high-order differential equation. Chico Solver solves the equation in a manner that is transparent to the user by effectively blurring the distinction between algebraic and initial value and boundary value problems—a great convenience.

The program shields the user from its internal workings, which I find a mixed blessing. Users cannot choose convergence criteria or other internal parameters; the manual provides no information about the algorithms employed.

I used Chico Solver (Version 2.07) for various problems, with computers ranging from a slow laptop model to an 80386-based PC with math coprocessor. The program ran smoothly, despite requiring a lot of disk operations. Contact: Chico Software Co., Box 5174, Chico, Calif. 95927-5174; 916-342-3279, or circle 105. The same product (same software and documentation) is available under the name SolvEq from Biosoft, Box 10938,

Ferguson, Mo. 63135, 314-524-8029, or circle 106.

Kenneth R. Foster (F) is associate professor in the department of bioengineering of the University of Pennsylvania in Philadelphia.

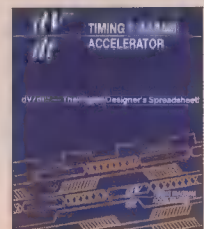
For timing diagrams

By Ahmed Rahil Khan and David L. Walker

A digital designer/computer engineer will find dV/dt a very useful tool. It supports the drawing of all the possible kinds of signals in a digital design. It also has an excellent

dV/dt Standard.

Software for creating timing diagrams. IBM AT or compatible, IBM PS/2 Models 20 and 30. DOS 3.0 or higher; 640K memory. \$695.



user interface, with pulldown menus and mouse-controlled icon choices that certainly attracted Macintosh lovers like us to the IBM PC. We could sketch, edit, analyze, and print diagrams with the click of the mouse button. In two approximately 2-hour sessions, we reached the advanced features.

We also created a clock signal very easily. The program handles the signal's timing parameters efficiently and clearly displays time intervals between any two edges on the signal. Also prominent is its ability to incorporate propagation delays.

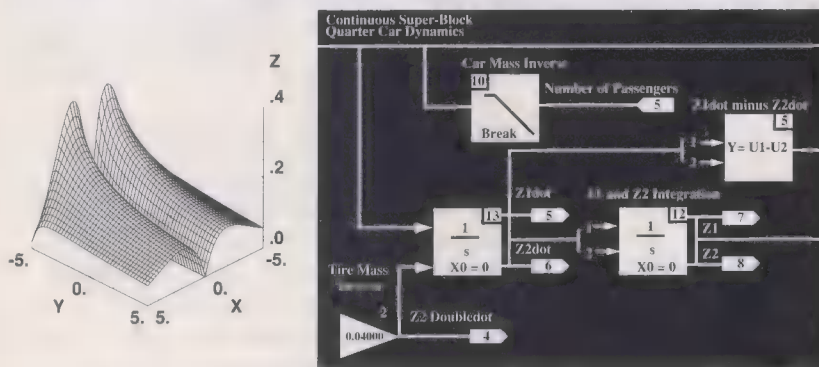
Another useful parameter is the available time—the time between two edges of the same signal or between two different signals. This is readily displayed and helps in determining whether or not a setup time for a signal was "missed."

The only problem arose when we created a clock (the first signal in a file) with a very high frequency. We had to zoom in half a dozen times before it was visible. We feel the program should automatically change the scale on the spread frame to zoom in, especially when the signal created is the first one in the present file. The signals that follow will almost always be in the same frequency. Contact: Doctor Design Inc., 5415 Oberlin Dr., San Diego, Calif., 92121-1716; 619-457-4545, or circle 107.

Ahmed Rahil Khan and David L. Walker are graduate students in the department of electrical and computer engineering at West Virginia University, Morgantown.

COORDINATOR: Gadi Kaplan

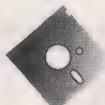
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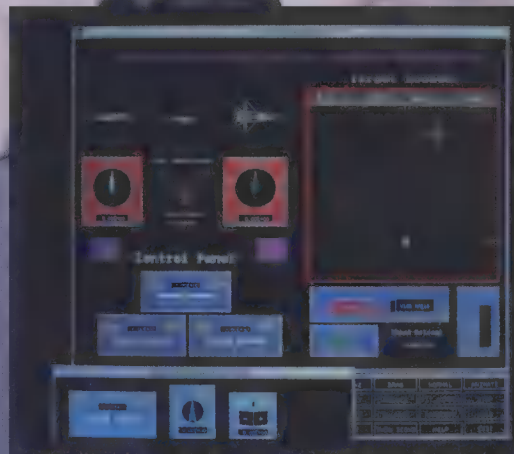
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Spectral lines

MAY 1991 Volume 28 Number 5

Moving on metric

It was just about a year ago when we announced on this page that we were saying "goodbye" to the inch [March 1990, p. 23]. At that time we noted that henceforth human beings would be measured in metric (SI) units, and airplane altitudes specified in kilometers.

Not all readers were sympathetic. One wrote "*IEEE Spectrum* would be well advised to retract the Big Brother theme and adopt the course that would best communicate with the readers." Another said "*Spectrum* may be saying 'Goodbye, inch,' but the engineers, technicians, and merchants who make things function are not throwing away their inch drafting tools, inch rulers, and inch calipers."

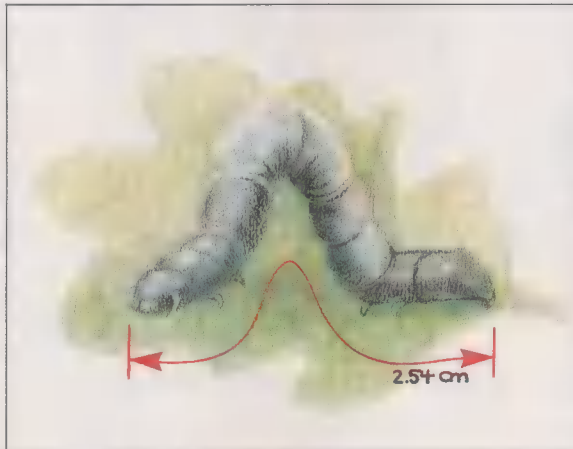
A pilot noted that "it is highly inaccurate and just plain dangerous to refer to an altitude as about 10 kilometers, not 33 000 feet." Feet and miles are the standards internationally, he said.

Chastened, we sought help from Bruce B. Barrow, chairman of the committee that developed the ANSI/IEEE Std 268-1982 on metric practice, and he came to New York City to present a day-long seminar for the *Spectrum* staff. He underscored the value of the International System (SI) for a publication like *Spectrum*, precisely because SI supports *Spectrum's* primary objective of clear communication with its readers. "We now have one measurement system coming into use worldwide. Countries outside the United States, with tens of thousands of IEEE members, are moving aggressively toward exclusive use of SI units," he said, adding, "We therefore have the responsibility of making our U.S. members, as well, more familiar with SI. It's not just a question of maximizing comfort for the majority of readers—we should be willing to push them a little bit." And he also emphasized that the familiar units in a narrow specialty are not necessarily the most easily comprehended by most readers. "Nobody is suggesting that air traffic controllers give instructions to pilots in kilometers, but most *Spectrum* readers are not pilots, and have a better 'feel' for 10 km than for 33 000 ft."

Many matters of metric style involve editorial judgment and cannot be treated

fully in a rigid document like a standard. When to use a symbol, as opposed to writing a unit name in full, for example, is an editor's (or author's) decision and requires that a particular publication know its audience. In the case of *Spectrum*, for example, we will assume that the readers are so familiar with kilometers, megahertz, volts, and other common SI units that their symbols are sufficient. But more obscure units, like the becquerel, may need to be spelled out on first reference.

Seldom if ever, however, should it be necessary to show the English equivalent of a measure given in SI units, Barrow believes. And in certain cases it is unnecessary to show the metric equivalent of a measure given in English units, as in the case of TV picture tube sizes. But the process of converting to metric is a dynamic one, so that as usages change with time, the acceptance of certain nonmetric units may wane or disappear.



The use of "duals"—an item in one measurement system followed by its parenthetical conversion—has other drawbacks. Two things come into play, Barrow notes. The reader may be jarred and slowed down, and it provides a crutch so that the reader doesn't start thinking metric.

As we reviewed our practices, it appeared that there are certain rules that *Spectrum* can follow unequivocally, while others may require situational judgment or may fall into the category of "metric dynamics"—meaning that present usage may cause us, at least for a time, to stay with English units.

Here are a few of the absolutes.

- Lengths will be given by the abbreviations

mm, cm, m, and km. We will avoid exotic prefixes like exa- and peta- by sticking to three significant figures—units, tens, or hundreds—and then multiplying by powers of 10 to allow the amount to be expressed in commonly used units, like those above. (This same rule will apply to other units, like megavolt, volt, and kilovolt.)

- Where tons are needed, the metric ton will be the norm. It will be used upon first mention in a given context. Thereafter "tons" will be assumed to be metric tons.

- Degrees Fahrenheit will not be used.

- Heights of persons will be given in cm.

Among those practices that will be continued until convention and/or the revised metric standard dictates otherwise are these:

- Kilowatthours are what electrical energy is sold in. We'll keep it.

- We'll try our best to present experimental data in metric units only, even though they may have been recorded in English units. An exception might be when the measurement standard relates to an English unit, as in the case of time required to accelerate to 60 mph.

- We'll drop acres in favor of square kilometers.

- Volumetric capacities, like auto trunks and refrigerators, will be specified in liters (they're closer in size to quarts than are cubic meters). Bigger volumes, like storage tank capacities and air cargo spaces, on the other hand, will be specified in cubic meters. The old standby, barrels of oil, will be replaced by cubic meters. We'll specify gasoline "mileage" in kilometers per liter, or, perhaps occasionally use the European inversion, gasoline consumption in liters per 100 kilometers.

- For physical measurements of devices and parts, we'll attempt to stick with current practices of the electronic manufacturing industries both in the United States and overseas. If the *ad hoc* international standard is English, there seems little point in converting it, even in parentheses.

Converting to metric may not be as neat or simple as we thought when we said "Goodbye, inch," but it can be more fun, as someone undoubtedly once said, than 0.159 m³ of monkeys.

Donald Christiansen

Smart cars and highways go global



David Schmitz

Rapid progress in controls, communications, and computers makes practical technical solutions to highway problems possible

New York's Long Island Expressway has been called the world's longest parking lot, but it may no longer have that dubious distinction. Most of the world's major highways are bogged down with traffic, not only in the morning and evening rush hours, but at many other times of the day. The clogged arteries lead to deaths and injuries from ac-

Ronald K. Jurgen Senior Editor

cidents, air pollution, wasted fuel, lost productive manhours, and motorists' frayed nerves.

A 1986 traffic study of 29 major U.S. cities by the Texas Transportation Institute, College Station, estimated that US \$24 billion per year was lost in those cities alone because of congestion. In each of the nation's 12 largest metropolitan areas, losses exceed \$1 billion per year.

The great hope for alleviating some or all of these conditions is a concept called Intelligent Vehicle-Highway Systems (IVHS) in the United States and Road Transport Informatics in Europe. Japan has similar programs. The basic goals of these programs are the same: to incorporate a range of technologies and ideas to improve mobility and transportation productivity, enhance safety, maximize the use of existing transportation facilities and energy resources, and protect the environment.

Underlying those goals is the realization that in most urban-suburban areas, building new highways is no longer an adequate answer (though they are an appropriate response in other situations). Indeed, in many geographical locations throughout the world, there is no room for new highways—even if they were to be deemed necessary and funds for them were available.

If there are deterrents to IVHS, they probably will not be technological. The rapid progress in computers, communications, and controls makes possible practical technical solutions to many highway problems that would have been unattainable not too many years ago.

Some of the needed IVHS components have already been put in place on a limited basis—traffic signal controls, vehicle identification systems, automatic toll charging, and a variety of driver information and navigation aids, for example. But IVHS would use an overall systems engineering approach to implement, step by step over perhaps the next 25–30 years, a logical approach to the ultimate scenario of smart cars on smart highways.

The IVHS benefits will come about only if the infrastructures for it can be put in place. Europe and Japan are also planning and demonstrating such systems. But what may prevent IVHS from becoming fully implemented anywhere in the world is the need for large capital investment from government agencies—Federal, state, and local in the United States, for example—and from equipment manufacturers willing to gamble on a new, largely unguaranteed market.

Forming a cloud over the socioeconomic IVHS scene is concern about potential legal liabilities and the costs of liability insurance. No one knows for certain what those liabilities will be once drivers no longer rely solely on themselves for routes taken and the control of their vehicles.

The first part of this report examines the various aspects of the IVHS dream, the general plans for its fulfillment, and the needed technological developments.

The second part explores what IVHS components are already in place as well as those planned throughout the world. It also describes some of the equipment now being used.

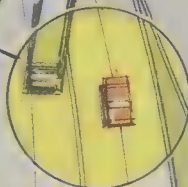
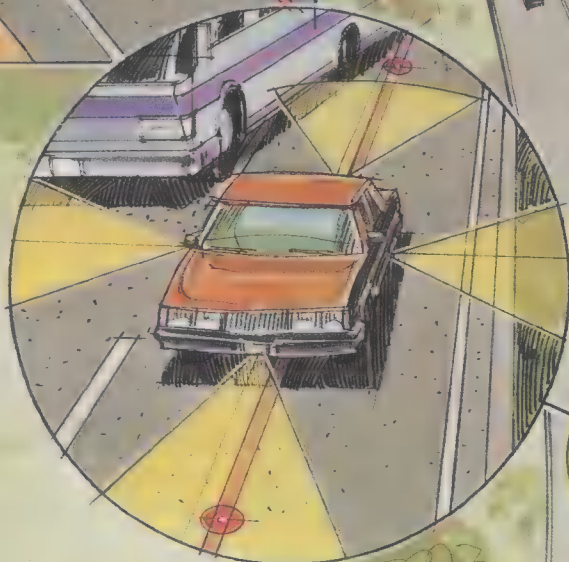
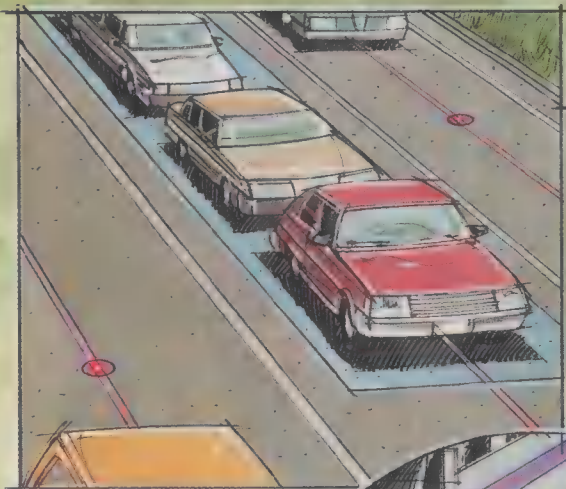
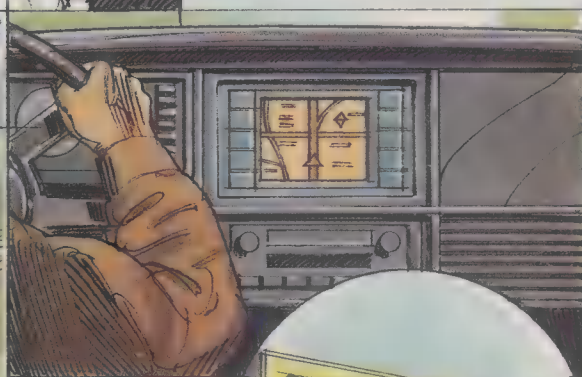
The final section addresses some of the socioeconomic aspects of IVHS and what effects they may have on successful implementation of IVHS worldwide.

Tomorrow's smart highways

When IVHS is fully implemented, it could look like this, complete with vehicle identifiers, automatic toll gates, overhead beacons, platooning of vehicles, traffic management centers, collision warning equipment, and variable message displays.



Barry Ross



Barry Ross

What IVHS should accomplish

Among the program's features are advanced traffic management, advanced traveler information, advanced control, and commercial vehicle operations

At the University of Michigan's Automotive Management Briefing conference in Traverse City, Mich., last August, Robert D. Ervin, co-director of the University of Michigan's IVHS program in Ann Arbor, explained how IVHS would make transportation safer and more efficient.

It will employ electronic communication for automated route guidance, toll collection, hazard warnings, fleet dispatch, a directory of commercial services, collision avoidance, and other functions, he said, and eventually will encompass automated driving with full-time automated control. Such features, Ervin pointed out, would come into use gradually, with one being implemented after another, in an effort to gain more favorable cost/benefit ratios through "economics of synergy" as each feature is added. The crucial questions now, he said, involve the form these systems will take and the timing within which they will be implemented.

Infrastructures in Europe and Japan have been in preparation for some time to accomplish similar objectives. Europe's route-guidance demonstration programs and Japan's motorists' navigational aids came about through carefully orchestrated government-industry cooperative ventures. The U.S. infrastructure for ■ systems approach to IVHS, however, is just being formed, but the momentum has increased in recent months.

The leading impetus for IVHS in the United States has been Mobility 2000, an informal assembly of interested individuals from government, industry, and educational institutions. The group has sought to define a national cooperative program to advance technological development that would address highway problems. Hoping to focus attention on IVHS issues and opportunities, it also sponsored meetings in San Antonio, Texas, in February 1989 and in Dallas in March 1990.

The work of Mobility 2000 was stimulated by some state agencies in the United States, particularly the California State Department of Transportation, and by major IVHS projects under way in Europe and Japan. For example, the European Commu-

nity (EC) is now coordinating the Road Transport Informatics projects.

One of these is a program called Dedicated Road Infrastructure for Vehicle Safety in Europe (Drive). A key objective of the EC is to integrate Drive with the industry-sponsored projects of Eureka, the \$5 billion, 19-country organization for European research and technological cooperation. Eureka's best known IVHS-type program is the Program for a European Traffic with Highest Efficiency and Unprecedented Safety (Prometheus).

In Japan, the two major projects have been Advanced Mobile Traffic Information and Communication Systems (Amtics) and Road/Automobile Communication System (RACS). Amtics and RACS (now in the process of being combined into a project called Vehicle Information Communication System or VICS) combine vehicle navigation with real-time traffic information.

With these programs being implemented, Mobility 2000 members feared that unless the United States established an active IVHS program, it would be entirely dependent on non-U.S. developments.

A COORDINATING ORGANIZATION. At a National Leadership Conference on Implementation of IVHS held in Orlando, Fla., last May, there was strong endorsement for a formal organization to coordinate the IVHS R&D efforts of public and private groups. As a re-

sult, IVHS America, headquartered in Washington, D.C., was incorporated in August. It had its first steering committee meetings in the summer, and was designated a nonprofit educational and scientific association in November by the Internal Revenue Service.

IVHS America has been chartered as ■ formal advisory committee to the U.S. Department of Transportation. As a so-called "utilized" Federal advisory committee, it provides advice and recommendations

to the department on its IVHS program. But there are broader objectives as well. IVHS America is to define goals, strategic plans, and programs for the development and implementation of IVHS in North America. Plans also call for the organization to set priorities for R&D activities, address legal and institutional issues, and coordinate international cooperation. It will also identify and develop needed standards, help alleviate state and local jurisdictional conflicts, and determine system architectures and roles.

Mark Norman, IVHS America's acting executive director at the time (James Constantino is now the executive director), told *IEEE Spectrum* that Mobility 2000 was folded into this organization as its technical arm. **FOUR MAIN AREAS.** In its executive summary of the March 1990 meeting in Dallas, Mobility 2000 described how IVHS programs cover four broad, interrelated areas:

- Advanced traffic management systems (ATMS) permit real-time adjustment of traffic control systems and variable message signs for driver advice. Their application thus far in selected corridors has reduced delay, travel time, and accidents.
- Advanced traveler information systems (ATIS) perform a variety of functions, including navigation using electronic maps; route selection and guidance; information on services such as gas stations, restaurants, and hospitals; and real-time traffic information through communication between drivers and ATMS.

- Commercial vehicle operations (CVO) systems add to ATIS those features critical to commercial and emergency vehicles. They expedite deliveries, improve operational and regulatory efficiency, and increase safety. When fully developed, CVO systems will be designed to interact with ATMS.

- Advanced vehicle control systems (AVCS) apply additional technologies to vehicles—adaptive cruise control, night-vision sensors, radar, automatic braking, for example—to identify obstacles and adjacent vehicles and, ultimately, to prevent collisions with them. AVCS will interact with ATMS

to provide automatic vehicle operations.

ATMS encompass traffic detection, communication, and control. A surveillance system monitors traffic conditions and sends data about those conditions to ■ traffic management center. There the data is processed and combined with information from other sources—which would include specially equipped vehicles in the traffic stream.

The processed information is used for several purposes: to advise drivers about current and expected traffic conditions; to

A 20-minute tieup could waste over 2000 vehicle-hours, cause a 3-kilometer backup, and take 2.5 hours to clear

The Ali-Scout System

The Ali-Scout System (now renamed Euro-Scout) is a three-in-one system that handles advanced traffic management, route navigation, and driver information. Developed by Siemens Automotive, an operating unit of Siemens AG, Munich, it uses infrared transmitters and receivers to transfer navigation information between roadside beacons and on-board displays in appropriately equipped vehicles.

The system's infrastructure equipment includes the IR beacon transmitter-receivers located on traffic lights and linked to a central control facility where computers originate the system guidance information.

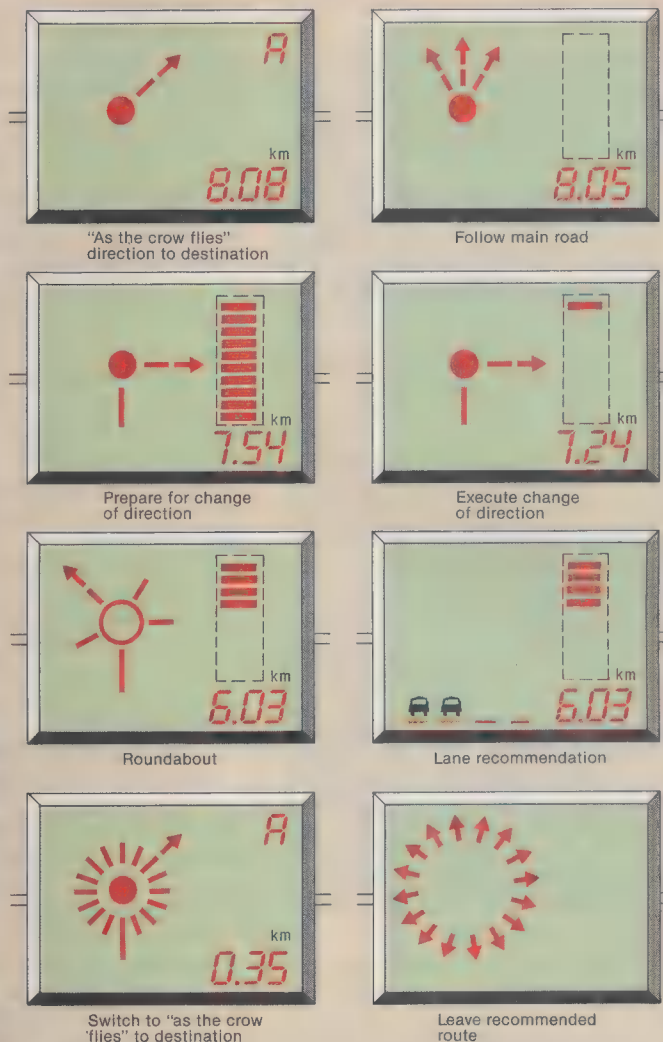
The in-vehicle unit includes an input keyboard, a small arrow indicator guidance display, and a voice messaging system. Unseen by the driver are an on-board computer for the dead-reckoning navigation system and an infrared transmitter-receiver.

The transmitter-receiver picks up traffic data as it passes a beacon and also sends data back to the central computer, where they are factored into the degree of route congestion and travel time for all suitably equipped vehicles on all beacon-to-beacon links. The computer also factors in the historical congestion profiles, including pedestrian traffic for that intersection. The information can then be used to adjust traffic light timing to smooth overall flow throughout the system.

Ali-Scout does not use map displays but does store an up-to-date map of the city in its central computer. It continually computes a driver's minimum trip time route and transmits that information to his car.



Siemens Automotive (photos)



Source: Siemens Automotive

In-vehicle display (right) gives the driver a number of informational displays (drawing). Explicit directions—get in the right lane, turn right, and so on—will be displayed for getting to the destination the driver has input via the keyboard (above). When the vehicle is outside the digital map area, an arrow is displayed showing "as the crow flies" direction to the destination, but the driver has to determine which roads to take.



inform drivers of the location, severity, and expected duration of incidents; and to recommend the best routes for drivers to take to reach their destinations. It is also used to develop ramp metering rates and traffic signals that are adaptive to real-time traffic conditions, and to implement the best control strategies.

The Mobility 2000 summary emphasizes that traffic management during incidents may bring the most dramatic results because an accident blocking one of three lanes reduces overall capacity by 50 percent. For example, a 20-minute blockage during non-rush hours could waste 2100 vehicle-hours, cause a backup over 3 kilometers long, and take 2.5 hours to clear.

ATIS equipment will inform motorists of current traffic conditions and provide real-time guidance on route decisions through use of visual or auditory systems installed in vehicles. ATIS will also provide safety advisory and warning messages as well as an on-board directory of motoring information.

Other ATIS features will include electronic vehicle identification for toll debiting; on-board databases with detailed maps, a business directory, and locations of services and hospitals; assistance for aged drivers; and "Mayday" signaling and response capabilities in emergencies.

A necessary step will be to integrate ATMS and ATIS to determine if there is a synergistic result.

Weigh-in motion sensors, automated vehicle identification transponders, and automated vehicle classification devices will reduce the time spent in weigh stations, cut labor costs to states, and minimize red tape for commercial operators.

Commercial vehicle operators are already using these technologies to some extent as well as routing algorithms for dispatch and in-vehicle text and map displays.

Basic AVCS augment driver performance by detecting the presence of obstacles or

other vehicles and warning drivers of loss of alertness and impending collisions.

Second-generation AVCS will implement lateral and longitudinal vehicle control functions in such applications as high occupancy vehicle lanes. Vehicles would enter the lanes under manual control, but once there would be under full or partial automatic control. This would allow increased speed, improved safety, fewer collisions, and platooning or linking of a group of vehicles.

Third-generation AVCS would completely automate driving functions for vehicles on specially equipped freeways. This would include automatic chauffeuring of vehicles from on-ramp arrival to off-ramp departure, increasing traffic flow in the high-demand urban and intercity traffic corridors, and improving safety and mobility with high-speed operation in interstate travel.

IVHS BENEFITS. According to Mobility 2000, ATMS reduce stop-and-go traffic by up to 30 percent (others say 20 percent is more realistic) and reduce travel time from 13 to 45 percent, while ATIS cut another 10 to 15 percent from travel time. CVO systems lead to more efficient truck operations, and AVCS will help to further reduce accidents and increase traffic flow.

By reducing traffic congestion, air quality will improve, driver stress will fall, and productive man-hours will increase.

IVHS will advance safety by helping prevent off-road accidents as well as angle, head-on, rear-end, and side-swipe collisions. This will be accomplished with electronic imaging systems that sense the locations of lane boundaries and radar systems that detect oncoming vehicles and control braking.

WHAT WILL IT COST? The Mobility 2000 executive report recommends a total IVHS investment of \$35 billion (in constant 1990 dollars) for R&D, field tests, and implementation for the years 1991 through 2010. Operation and maintenance costs would add about another 15 percent to that amount.

The \$35 billion investment would cover:

- Instrumentation of 29 000 km of freeways with 200 000 signalized intersections in 250 large metropolitan areas.
- Communications systems to interact with ATIS in those 250 metropolitan areas and in rural areas in every state, plus a statewide traffic control center to monitor incidents on the intercity network of roads.
- Instrumentation to interact with CVO systems on the 68 500-km Interstate System and the roads in the National Network for Trucks.
- Systems to interact with AVCS in 16 platooning highway systems.
- Forty-four electric-propulsion highway systems in 40-km increments in the most congested metropolitan areas with a population over one million.

In addition, a consumer investment of \$800 to \$1200 per vehicle would be required to add ATIS equipment.

Lyle Saxton, chief of the Advanced Systems Division, Federal Highway Administration (FHWA), Washington, D.C., which was established in 1990 to manage the FHWA's program in IVHS, told *Spectrum* that he recommends three IVHS actions:

- Push deployment of state-of-the-art traffic management systems. Less than 20 major U.S. cities, he said, have good or even reasonably good traffic management capability.
- Aggressively develop and deploy driver information systems.
- Substantially increase R&D for ATMS, ATIS, CVO, and, especially, AVCS.

Saxton emphasized to us that most conventional approaches to relieve congestion, improve safety, and decrease pollution—like more roads in urban areas, seat belts, and exhaust emission controls—have reached the point of diminishing returns. IVHS is not a cure-all, he said, but it is the next step to breaking out of the flattening curve for conventional fixes. ♦

SPECIAL REPORT/TRANSPORTATION

Testing the concepts worldwide

A variety of projects in Europe, Japan, and the United States aim at proving the feasibility and practicality of IVHS

While the United States maps its IVHS strategies and embarks on independent demonstration projects, Europe and Japan are moving forward with major funding in place and scores of coordinated projects under way.

Prometheus is a \$700 million pre-competitive research project started in Oc-

tober 1987 by 18 European carmakers. The project also includes vehicle-oriented research supported by 40 research institutions and by the European electronics industry, traffic engineering agencies, and telecommunications agencies.

In 1989 a six-year R&D phase consisting of seven subprograms began. Three of these are applied research programs under the supervision of automobile companies:

- Pro-Car—a program developing vehicle-monitoring and intelligent driver aids: sensors and signal processing (Saab), actuators and vehicle operation (Fiat), general architecture (Peugeot), man-machine interfaces (Saab), and vehicle safety and dependability (BMW).

• Pro-Net—a program developing a communications network between vehicles: system engineering (Volkswagen), communications (Renault), and emergency warnings (Saab, Volkswagen, Daimler-Benz).

■ Pro-Road—a program developing communications systems between the vehicle and roadside infrastructure and traffic control systems: information processing and data acquisition (Volvo), infrastructure-based systems (Daimler-Benz), and on-board elements (Renault).

The other four subprograms involve applied research:

- Pro-Chip—a program developing micro-electronics for information systems.
- Pro-Art—a program clarifying the require-

ments for artificial intelligence.

- Pro-Com—a program defining the structure, standards, and architecture of communications systems.
- Pro-Gen—a program analyzing traffic scenarios.

The results of this research will be integrated in what are called Common European Demonstrators (CEDs) that incorporate vision enhancement, proper vehicle operation, collision avoidance, autonomous and infrastructure-supported route guidance, public information services, and commercial fleet management.

Two CEDs planned are an autonomous intelligent cruise control that will maintain a safe distance between the vehicle in which it is installed and those ahead of it, and a post-accident system that will alert vehicles coming from behind to avoid secondary accidents. It will also call rescue services automatically via a cellular telephone.

Drive I is a three-year (1989–1991), \$140 million infrastructure-oriented program with about 70 projects defined. Its principal objective is to develop standards and functional specifications supporting such needs as route guidance and other driver information aids, advanced traffic control, fleet management, automatic toll collection, and road pricing.

The 70 projects fall under seven categories: evaluation and modeling; behavior aspects and traffic safety; traffic control; route guidance, vehicle location, digital maps, and in-vehicle information systems; public transport and freight management; telecommunications; and consensus formation.

Major Drive projects include:

- The System of Cellular Radio for Traffic Efficiency and Safety (Socrates)—a program investigating using dedicated channels from the pan-European GSM system to broadcast information to vehicles. The same data set is broadcast to all equipped vehicles in a particular cell. To provide transmission from vehicles to the control center, a multiple-access protocol is used. Initial tests in Gothenburg will be completed this year.
- Traffic and Roads-Drive Integrated Systems (Tardis)—a project establishing common functional specifications for systems that are not wholly vehicle-based and that depend on communication between vehicles and roadside infrastructures. It includes investigating the possibility of combining communication for route guidance with that for automatic debiting (toll collecting).

Drive II is scheduled for 1992 through 1994. With funding of \$280 million—twice that of Drive I—it will focus on demonstrating projects investigated in Drive I.

OTHER EUROPEAN PROJECTS. Prometheus is the largest IVHS program under Eureka's aegis but other European programs include:

- Trafficmaster—an information system for drivers developed by General Logistics PLC using Britain's M25 London Orbital Motorway and interconnecting motorways that

The Trafficmaster system

Trafficmaster, from General Logistics PLC, Luton International Airport, Bedfordshire, England, is a real-time traffic information system that provides motorists with up-to-the-minute information on the speed, direction, and length of any traffic backup. It enables drivers to assess the situation and take avoiding action, if desired, but does not suggest what evasive action to take.

The system uses infrared sensors mounted on highway bridges at approximately 3-kilometer intervals that log the speed of traffic passing below them. Each unit illuminates two detection zones with encoded streams of infrared light. If the speed drops below a preset threshold of 40 km/h, the sensors relay that information over a radio link to the control center. From there the information is transmitted by means of a radio paging network to a receiver mounted on the dashboard of the vehicle.

The receiver displays the information in map form, giving the driver an audible and a visual signal as soon as updated information is received. The display then zooms in to a close-up map of the area where the problem is occurring—a flashing block shows the location, speed, and direction of the holdup while the number of blocks denotes the length of the backup. Information is updated every three minutes.

The unit can be programmed to begin updating information before the motorist starts out. He or she simply selects the zone of the highway for which information is required.

An integral personal-message paging facility has been incorporated into the system; it is based on the radio paging network. The display can store up to 50 unread messages.

The cost of Trafficmaster to the subscriber is £295 (US \$580) for the receiver plus a monthly subscription charge of £18.5.

lie within a 56-km radius of London [see box].

- Autoguide—a dynamic route guidance system based on a network of short-range beacons connected to a control center based on the Ali-Scout concept [see box]. A consortium headed by GEC Marconi will implement and operate Autoguide.

A demonstration system in London consists of five independent beacons covering part of central London and the route to Heathrow Airport and 15 vehicles equipped with Autoguide units. A large-scale pilot installation with 200–300 beacons and 1000 vehicles is planned soon. If that is successful, the system will be expanded to 1000 beacons.

- LISB—Leit und Information System Berlin is the main project using the Ali-Scout concept. It is funded by the German Government and the senate of Berlin. Infrared communications beacons at 250 intersections in and around Berlin transmit traffic-dependent routing information to 700 equipped vehicles as they pass the beacons.

- Europolis—a seven-year, \$150 million project shared by Denmark, France, Spain,

General Logistics PLC



The Trafficmaster display is a high-contrast, super-twist liquid-crystal display with a viewing area of 101 by 82 millimeters. Its resolution is 160 by 128 pixels. The display and its associated keypad are both backlit with electroluminescent panels.

and Italy that encompasses intelligent systems for traffic monitoring and control, automated road systems, and automated driver functions.

- Carminat—a car-monitoring and navigation system that integrates information stored on CD ROMs, information received from vehicle sensors, and information received from radio broadcasts.

▪ European Road Transport Information System (Ertis)—a program to develop systems that automatically communicate motor freight information like truck locations, speed, road conditions, fuel consumption, and destinations to head offices.

JAPAN'S PROGRAMS. In Japan, Government agencies heavily involved in the country's Info-Mobility projects include the Ministry of International Trade and Industries, the National Police Agency, the Ministry of Construction, and the Ministry of Posts and Telecommunications.

The police agencies in 74 Japanese cities already operate traffic control and surveillance systems. In Tokyo, for example, the amount of traffic congestion and queue lengths are calculated on the basis of traffic

volume and speed data obtained from roadside vehicle detectors. This information is used to determine online traffic signal controls and the content of messages for variable message signs and roadside broadcasting of driver information.

Several phases of Japan's two major in-vehicle information systems programs, RACS (expressways) and Amtics (surface streets), have been completed and are now being evaluated. The results of that evaluation will determine what direction the new VICS program will take.

RACS, a 4 billion yen (US \$30.3 million) project which uses dead-reckoning with map-matching and maps stored in CD ROMs, was initiated in 1984. From 1986 to 1988 the Ministry of Construction formed a joint R&D project with 25 private companies. In 1987 and 1988 two field tests were conducted using a digital road map database and inductive radio and microwave beacons. From 1989 through June 1990 an integrated experiment was conducted.

RACS is based on a two-way digital communication system using microwaves in the 2.5-gigahertz band. It provides in-vehicle navigation, information services, and individual communication. The results of the map-matching are displayed on a cathode-ray-tube (CRT) terminal in the vehicle. Location data are transmitted from roadside beacons to correct accumulated errors inherent in dead-reckoning systems. A recent decision of the Ministry of Post and Telecommunications in Japan will limit RACS to a one-way communications system.

The beacons are tied in with a road traffic information center so that traffic information can be updated.

About 50 corporations participate in Amtics, for which total expenses have not been released. A traffic control center transmits traffic congestion information by using the down-link part of the Teleterminal System, a cellular digital packet system with 3-km radius areas. The signals are transmitted at 4.8 kilobits per second at 800 megahertz.

For accurate information, additional 13-GHz microwave radio units called sign posts are used. Like RACS, Amtics uses maps stored in CD ROMs and CRT display terminals. The Teleterminal System provides real-time information on traffic conditions, weather, and available parking spaces. In addition to showing maps, the CRTs display local traffic regulations, locations of gas stations, and tourist information.

An Amtics experiment was conducted in central Tokyo in 1988 with about 12 different versions of in-vehicle equipment. In 1990 a second demonstration involving 34 vehicles took place at the Osaka Flower and Greenery Exposition. Each demonstration reportedly cost about 300 million yen.

THE U.S. APPROACH. U.S. government funding of IVHS was only \$4 million in fiscal year 1990 and \$20 million in 1991. The request to Con-

gress for 1992 is \$50 million. This small investment, compared to that in Europe and Japan, covers only R&D and operational tests, not deployment of systems.

What is needed, according to the University of Michigan's Ervin, is the establishment of IVHS as a major goal of the national highway program. This, he said, would require action by the U.S. Congress in the Surface Transportation Act of 1992 with the funding coming from the Highway Trust Fund.

Despite the lack of large-scale funding, significant field demonstrations of IVHS have been announced and some are under way. Not surprisingly, the major projects are in locations with serious congestion problems and local agencies are heavily involved.

The Smart Corridor Demonstration project in southern California is sponsored by the California Department of Transportation (Caltrans), the California Highway Patrol, the Los Angeles Police Department, the Los Angeles County Transportation Commission, and the FHWA.

The \$50 million project began in 1987 to integrate traffic sensors, computers, and communications links to coordinate traffic and give drivers information for the Santa Monica

U.S. government
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Freeway and five major arterials between downtown Los Angeles and the San Diego Freeway, 23 km to the west. Full implementation is set for 1992.

Anticipated benefits of the project include reductions of 3.8 to 5.2 million vehicle hours per year in total travel time, 1.3 million gallons per year in fuel consumption, 300 000 kilograms per year in emissions of hydrocarbons, and 4 million kilograms per year of carbon monoxide. Average freeway speeds during peak commuting hours are expected to increase from 25–55 km/h to 65–80 km/h. Annual savings due to reduced travel time and fuel consumption (based on fuel costs of \$1 per gallon and time costs of \$6 per vehicle-hour) would be \$24 million to \$32.5 million.

The Smart Corridor is the test site for the three-year Pathfinder project. Sponsored by Caltrans, FHWA, and General Motors Corp., Pathfinder is an in-vehicle motorist information and road navigation system [see box]. Caltrans has budgeted \$900 000 for field testing, evaluation, and the final report, while the

FHWA has provided \$750 000 to fund the system design and installation. General Motors is supplying the vehicles and ETAK Inc., Menlo Park, Calif., is loaning Travelpilots for those vehicles.

The project provides drivers of 25 specially equipped Oldsmobile 88s with up-to-date information about accidents, congestion, highway construction, and alternate routes.

The Pathfinder project is an initial test of an ATIS project in the United States. It has four main objectives:

- The design, installation, and operation of a system that will provide real-time traffic congestion information to motorists in their vehicles.
- The evaluation of the driver's response to the information provided.
- The evaluation of the utility of using vehicles as a source of traffic information.
- The evaluation of a computer-assisted method of combining real-time traffic information from various sources.

The Pathfinder system has three main elements: hardware in the vehicle to provide information to drivers, computers at Caltrans' traffic operations center to collect and process data from a variety of sources, and the communications system that transmits data to and from the vehicles.

The hardware in the vehicle is based on an ETAK TravelPilot, a navigational system that displays electronic road maps on a CRT display. It uses a self-contained navigation system based on dead-reckoning in combination with stored digital maps and map-matching software to determine the vehicle's location.

A six-month Pathfinder test program, completed late last year, had Caltrans employees commute to work in Pathfinder vehicles during peak hours along the Smart Corridor to test the system's usefulness in avoiding

traffic congestion. Another test phase will use hired drivers to travel between various origin and destination points to determine travel times with and without the equipment in operation.

After testing is completed, Caltrans will evaluate information on how drivers perceive and use the data, and on which modes of in-vehicle information (visual or audio) they prefer.

Another California project is the Program on Advanced Technology for the Highway (PATH). The \$56 million, six-year project, which began in 1986, is sponsored by Caltrans, the FHWA, and the National Highway Traffic Safety Administration.

PATH is investigating a national automated highway system, starting with gradually automating selected driver functions and ultimately embracing completely automated vehicle operations. The program includes roadway electrification, highway automation, traffic management, and driver information and navigation aids.

One PATH objective is to transfer energy

Representative major IVHS projects worldwide

Major IVHS projects in Europe			
Project	Landmark dates	IVHS systems	Sponsors
Prometheus start	1986	ATMS, ATIS, AVCS	Eureka
Prometheus R&D	1989-95		
Drive I pilot studies	1985	ATMS, ATIS, CVO	Commission of the European Community
Drive I tests	1989-91		
Drive II demonstrations	1992-94	ATMS, ATIS, CVO	
Trafficmaster deployed	1990	ATIS	General Logistics PLC
LISB concept	1985	ATIS	Siemens, Bosch, Federal government of Germany, Senate of Berlin
LISB deployed	1989		
LISB taken over by city government	1991		
Autoguide demonstration	1987	ATIS	General Electric Co. PLC
Travelpilot in Germany	1989	ATIS	Bosch, ETAK
Travelpilot deployed in the Netherlands	1990		

Major IVHS projects in Japan			
Project	Landmark dates	IVHS systems	Sponsors
CACS deployed	1973-79	ATMS, ATIS	Ministry of International Trade and Industry (MITI)
RACS started	1984	ATIS	Ministry of Construction
RACS R&D	1986-88		
RACS field tests	1987-88		
RACS demonstrations	1989-90		
Amtics Tokyo demonstration	1988	ATIS	National Police Agency
Amtics Osaka demonstration	1990		
VICS demonstrations	1991?	ATIS	Ministry of Post and Telecommunications

Major IVHS projects in the United States			
Project	Landmark dates	IVHS systems*	Sponsors
Smart Corridor project began	1987	ATMS, ATIS	Federal Highway Administration (FHWA); California Dept. of Transportation; California Highway Patrol; Los Angeles County Transportation Commission, Dept. of Transportation, Police Dept.
Smart Corridor conceptual design	1989		
Smart Corridor full implementation	1992		
Pathfinder initiated	1988	ATIS	California Dept. of Transportation, FHWA, General Motors Corp.
Pathfinder test	1990		
Pathfinder experiment completed	1991-92		
Pathfinder expanded to Los Angeles region	1993-94		
GuideStar began	1988	ATMS, ATIS	Minnesota Dept. of Transportation, University of Minnesota
GuideStar demonstrations	1991-94		
GuideStar expansion	1997-?		

Major IVHS projects in the United States (continued)			
Project	Landmark dates	IVHS systems	Sponsors
PATH began	1986	ATMS, ATIS, AVCS	California Dept. of Transportation, FHWA, National Highway Traffic Safety Administration, California Institute of Transportation Studies
TravTek announced	1990	ATIS	American Automobile Association, General Motors Corp., FHWA, Florida Dept. of Transportation, City of Orlando
TravTek demonstrations	1991-93		
HELP-Crescent feasibility study	1983-85	ATIS, CVO	Fourteen U.S. states, Port Authority of New York-New Jersey, Canadian province of British Columbia, U.S. national transportation agencies, U.S. and Canadian trucking industries
HELP technical studies	1985-89	CVO	
Crescent demonstrations	1990-92	ATIS	
HELP-Crescent national coverage	2002	ATIS, CVO	
Chicago	1991	ATIS	Illinois Dept. of Transportation, Motorola Inc., University of Illinois, FHWA, Northwestern University
Scandi operational	1980	ATMS, ATIS	Michigan Dept. of Transportation
University of Michigan IVHS	1987	ATMS, ATIS, CVO	Twenty U.S. and international companies; 7 Federal, national, state, provincial, and local authorities; 4 user and research organizations. Launched IVHS education program
	1990	ATMS, ATIS, CVO	
MTC (Met Detroit) IVHS testbed	1990	ATMS, ATIS	Michigan Department of Transportation
MTC Phase I field test on ATIS	1991	ATIS	
MTC Phase II field test on IVHS system architecture	1994	ATMS, ATIS	
Greater New Orleans Bridge deployed	1989	ATMS, ATIS	Amtech Technology Corp.
Dallas North Tollway deployed	1989	ATMS, ATIS	Amtech Technology Corp.
Drive by wire	1993	AVCS	To be determined
Obstacle detection	1997	AVCS	
Intersection hazard warning deployed	1999	AVCS	
Automobile Mayday	2000	ATIS	
Interactive control	2003	AVCS	
Lane-changing control	2011	AVCS	
Trip routing and scheduling	2011	ATIS	
Obstacle avoidance	2013	AVCS	

*ATMS—Advanced Traffic Management Systems; ATIS—Advanced Traffic Information Systems; CVO—Commercial Vehicle Operations; AVCS—Advanced Vehicle Control Systems.

The Pathfinder System

The Pathfinder System is a driver information system that informs motorists of existing traffic congestion.

The hardware in the vehicle for the Pathfinder System includes a processor, voice synthesis equipment, a modem, radio, and a Menlo Park, Calif.-based ETAK Inc. Travelpilot. This is a navigational system that displays electronic road maps. As the vehicle moves, its position on the screen remains fixed and the map moves around it, providing a view of the roadway ahead. The driver may view a particular area in greater or lesser detail by zooming the display in and out.

Drivers can enter a desired destination and it will appear on the map display. Map data are stored on a compact disc located in the vehicle. A separate computer in the vehicle is used to collect and sort the congestion data received by radio from the central system computers.

The received data are presented to the driver in three different ways:

- Symbols indicating congestion shown on the map screen.
- Text displayed at the bottom of the screen to indicate points of congestion ahead.
- Digitally recorded voice messages giving audi-

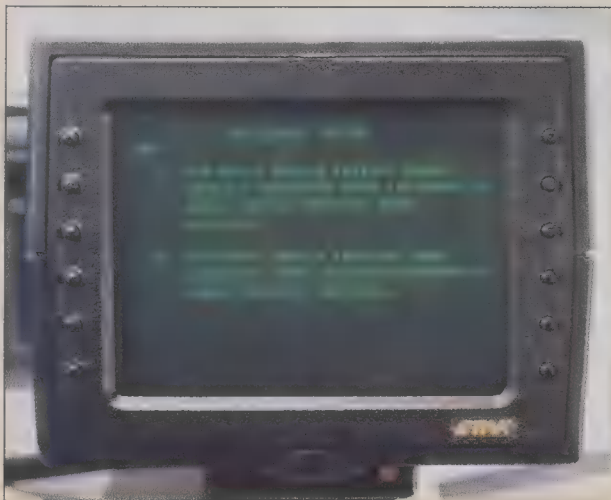
ble versions of the information shown in the text, relieving the driver of the need to constantly view the screen.

At the central workstation for the Pathfinder project in the traffic operations center, a computer is used to process congestion data from the arterial street computer, the freeway computer system, and the data being received from the Pathfinder vehicles—mean speed, number of stops, and other system parameters such as the number of button presses requesting and/or changing the mode of information display.

The operator at the computer is also able to provide other data relating to traffic congestion such as accident reports from the police, and specific maintenance and construction activities under way.

Data from all sources is integrated and accumulated into a list of locations and congestion levels. This information is broadcast to all vehicles once every minute. Each vehicle is then assigned a time slot within the minute for making a return transmission. When the vehicle's time slot arrives, data on position, heading, and speed are transmitted by radio back to the traffic operations center.

The ETAK Inc., Menlo Park, Calif., Travelpilot display used in the Pathfinder system presents traffic information on maps with symbols, by text, and also by recorded voice messages.



inductively from a conductor embedded in the roadway—a transformer primary—to a transformer secondary mounted below the automated vehicle. The inductively coupled energy would power the vehicle directly and/or recharge its storage batteries.

With an IVHS system, vehicles could be controlled longitudinally with minimum spacings between vehicles. For lateral guidance, the use of tracking of magnetic markers and guidewires embedded in the roadway is being investigated.

The over \$8 million TravTek (travel technology) project is being developed for the Orlando, Fla., area. It is a cooperative—and shared-cost—partnership of General Motors Corp., the FHWA, the American Automobile Association (AAA), the Florida Department of Transportation, and the city of Orlando. TravTek will be implemented for a one-year period beginning in 1992.

TravTek uses prototype, in-vehicle information equipment to provide motorists with up-to-date traffic information and directions to destinations. It will also provide useful information about Orlando-area attractions, accommodations, and services.

TravTek equipment will be installed in about 75 general-use GM rental cars and about 25 vehicles used by local drivers. The vehicles will receive continuous reports about current travel times, incidents, and congested routes. The TravTek equipment in the cars will use this data to provide efficient route guidance to the drivers.

The in-vehicle equipment consists of a video screen, two microcomputers, a voice synthesizer, and a radio for data communications. The video monitor may display any of the following:

- Maps of the Orlando area graphically representing the locations of traffic incidents and congestion.
- Directory information about hotels, restaurants, and services (including price range, AAA ratings, and location).
- Route guidance instructions using simple intersection schematics and directional arrows.

When drivers select destinations, the TravTek processor uses travel times to determine the best routes and uses both graphic displays and a synthesized voice to guide the drivers.

The traffic management center will combine and sort the traffic-related information received from a variety of sources throughout the Orlando metropolitan area, including the city of Orlando's centralized traffic signal system, the Florida Department of Transportation's freeway management systems, the AAA's TravTek information and service center, the police agencies in the area, the various departments responsible for maintenance and construction activities, and the TravTek vehicles.

From all this data, information on incidents—including travel times on affected routes—is estimated and transmitted to the vehicles. The in-vehicle processor then de-

termines if the driver's selected route is affected, calculates a new routing if necessary, and informs the driver that a revised routing is available.

The \$6 million Heavy Vehicle Electronic License Plate (HELP) Program and Crescent Demonstration Project is the most ambitious cooperative project in North America. It involves the states of Alaska, Washington, Oregon, Idaho, California, Nevada, Arizona, Colorado, New Mexico, Texas, Minnesota, Iowa, Pennsylvania, and Virginia. Also cooperating are the Port Authority of New York-New Jersey, the Canadian province of British Columbia, U.S. national transportation agencies, and trucking industry representatives of both the United States and Canada.

HELP's objective is to explore new technologies that may provide an integrated heavy vehicle management system. The focus is on five technologies: automatic vehicle identification, automatic vehicle classification, low-cost weigh in motion, data communications networks including on-board computers, and satellite communication data links.

HELP is divided into three phases. The first (1983-1985) consisted of feasibility assessments by the states of Oregon and Arizona. The second (1985-1989) involved technical studies of the five technologies. The third (1990-1992) is the Crescent demonstration that will provide vehicles and vehicle monitoring locations in a real-world highway environment.

The demonstration corridor is I-5 and I-10 from Washington to Texas with I-10 and I-20 links in Texas. A small number of locations in British Columbia will interconnect

with others at U.S. and international border crossing locations. There will be about 40 equipped sites and 5000 trucks with transponders.

The demonstration will use a network of sensors at state border crossings and other strategic locations to obtain information needed by the trucking industry for fleet management and control, business planning, and tax compliance. Information will also be

The control system handles routing, scheduling, steering, and speed, while the driver can read, write, or even sleep

available to government agencies for facility planning and management, vehicle taxation, monitoring of hazardous material movements, and vehicle size, weight, and speed enforcement.

A large-scale demonstration of advanced driver information systems has been proposed for the Chicago area. The Illinois Department of Transportation, Northwestern University, the University of Illinois (Chicago), Motorola Inc., and the FHWA are working together in planning a demonstration of IVHS technology.

The demonstration would focus on arterials to test alternative approaches to driver

information systems, dynamic traffic information acquisition, incident detection, and analysis and forecasting.

About 4000 business, government, and private vehicles would be linked to a traffic management center by a two-way mobile radio network. In addition to dead-reckoning equipment with map-matching, vehicles would contain a Global Positioning System satellite receiver for position calibration.

Routing software and traffic-dependent route guidance would be presented by synthesized voice and also displayed on a screen.

The actual start of the project is expected in the latter part of this year. **THE AUTONOMOUS VEHICLE.** The various IVHS technologies in various stages of demonstration throughout the world are paving the way for the introduction one day of a truly autonomous vehicle. It would be capable of operating in any traffic situation, while traveling from one point on a freeway to another, without driver intervention.

As envisioned by Steven E. Shladover of the Institute of Transportation Studies at the University of California, Berkeley, in a paper given at the International Congress on Transportation Electronics, Dearborn, Mich., last October, travel one day might be like this:

"...it becomes possible for travelers to make the entire freeway portions of their trips 'hands off.' At the first freeway on-ramp, the driver specifies the desired off-ramp (even if it is in another city) and the control system takes over the routing and scheduling of the vehicle, as well as its steering and speed control. The driver is free to read or write or even to sleep ...". ♦

SPECIAL REPORT/TRANSPORTATION

What could hold back IVHS

Social and policy issues present complex problems that have neither easy nor obvious solutions

If the numerous global IVHS demonstration projects throughout the world make a full-scale IVHS seem just around the corner, that impression warrants closer scrutiny. Many socioeconomic factors could delay or even arrest its development.

One institution that has analyzed this aspect of IVHS is the University of Michigan, Ann Arbor. Its IVHS Program, begun in 1987, is directed by research scientists Kan Chen and Robert D. Ervin, both in the College of Engineering. They and other members of the university faculty presented a series of papers on socioeconomic aspects of

IVHS at the Society of Automotive Engineers' meeting on Automated Highway/Intelligent Vehicle Systems: Technology and Socioeconomic Aspects, held Aug. 12-15, 1990, in San Diego, Calif.

One big issue cited by Chen and Ervin is legal liability. IVHS "will tend to reallocate liability for traffic accidents" by transferring some of the driver's responsibility to the electronic and vehicle manufacturers and the highway department, they said.

The question of legal liability was examined at some length by Kent Syverud, assistant professor of law at the university. His concern was whether the potential tort liability of IVHS manufacturers and highway owners—and the premiums necessary to insure against that liability—might delay or even scuttle IVHS innovation in the United States.

Syverud pointed out that courts in the

United States rely heavily on tort law to compensate automobile accident victims and that such accident lawsuits comprise almost half of all the lawsuits filed in courts of general jurisdiction throughout the United States.

When considering IVHS liability implications, Syverud emphasized, it is important to distinguish between driver information systems and systems that dilute driver control.

Driver-information systems aid motorists in their use of vehicles but leave decisions on how to operate the vehicles within their control. In this category would fall on-board guidance systems supplying maps or directions and information on traffic conditions; automatic toll-debiting systems; and collision warning systems.

Systems that dilute driver control, Syverud said, are applications of IVHS tech-

nology that in some circumstances override the driver's control of the vehicle. Automatic braking systems, external speed controls, headway-keeping systems, and collision avoidance systems fall into this category. Continuous control systems under which the driver may surrender all control of the vehicle to a central computer on a controlled highway are a special case.

Syverud gave an example of how liability in accidents involving collision-warning equipment might be allocated. With collision-warning systems, where a manufacturer equips a vehicle with a system that warns a driver of impending collisions, the most obvious liability comes from the failure of the manufacturer to install this technology on all its cars.

The second potential liability might arise when motorists who are sued for causing accidents claim reasonable reliance on an obviously malfunctioning collision-warning system and hence no negligence on their part. Manufacturers might reduce costs associated with such liabilities in a number of ways. They might use product warnings, over-engineer for safety, design the system to prove proper functioning, and rely on independent producers and/or installers. In addition, they could purchase insurance, get state legislatures to enact laws getting them off the hook, and get some kind of Federal preemption.

With systems that dilute driver control, Syverud said, responsibility for accidents is much more likely to be obscure, and "manufacturers and highway owners are much more likely to become defendants in tort suits." Controlled highways are the extreme case, he stressed. "The technology would convert automobile transportation... into communal transportation involving complex public risks." The liability risks associated with a system failure on a controlled highway "could well be unmanageable through liability insurance or self-insurance mechanisms."

Citing past experience in commercial air transportation, nuclear power, and commercial satellites, Syverud named Federal legislative initiatives that might be applied for controlled highways: immunity, liability limits, mandatory risk pooling, and indemnification.

CHICKEN-AND-EGG PROBLEM. Another problem addressed by Chen and Ervin is the "chicken-and-egg" standoff in the United States. On the one hand automotive and electronics industries doubt whether the public infrastructure for IVHS will ever materialize. On the other, highway agencies doubt whether IVHS technologies will deliver practical solutions to real highway problems.

This standoff, they said, is exacerbated by two factors. First is the reluctance of the automotive and electronics industries to target their R&D dollars at vehicle-side IVHS products whose "uncertain markets appear

to be out beyond the normally accepted three-to-five-year time horizon" of those industries. Second is that the "highway community is simply in a general state of financial distress since even the conventional needs of highway maintenance and operation substantially outstrip currently authorized tax revenues."

Another issue, Chen and Ervin emphasized, is the Bush administration's desire to reduce the budgetary deficit without raising Federal taxes. "The questions of who will take the leadership and who are to pay for what fraction of the IVHS program in the United States are far from being settled," they said.

Chen and Ervin identified other big IVHS issues—including maintenance of privacy and harmonization between IVHS and public transportation—as less important than the issues of institutional roles and legal liability.

At a lower level, they included specific financing mechanisms, the involvement of numerous governmental agencies at all levels, the generic formats for providing information to drivers, the degree of strategic and tactical controls remaining with the driver, and the timing as well as the process to set appropriate standards.

But can a 'dumb' vehicle negotiate a smart highway?

Among a host of intriguing policy issues mentioned by Chen and Ervin, are these:

- In route guidance, whether to optimize the system by minimizing total vehicle-hour delays, or to optimize things for the specific traveler by minimizing his or her delay.
- The question of jurisdictional boundaries between city, county, special district, state, and the Federal government in the operation of IVHS.
- The choice between electronic maps and directional arrows where directional arrows embody a recommendation from the traffic control center.

Additional IVHS social issues would include:

- Civil liberty and privacy issues. Will these systems track where people go? Will they track the speed at which people travel to their destinations?
- Insurance issues. If it can be shown by on-board sensors that on average a person is a good driver, has few close encounters, always wears a seat belt, and so forth, will that person get a lower insurance rate?
- Failure characteristics. Will IVHS degrade gracefully? What kind of performance will

be available when they are down?

- National security implications. If navigation requires nondegraded global positioning systems, will this have security implications?

TO PROBE FURTHER. Much of the information in this report was based on the following excellent sources.

The February 1991 *IEEE Transactions on Vehicular Technology* is a special issue on Intelligent Vehicle-Highway Systems (IVHS). Guest-edited by Lyle Saxton of the Federal Highway Administration, it contains technically detailed papers on the four major IVHS systems from experts worldwide. Copies are available from the IEEE Service Center, 445 Hoes Lane, Box 1331, Piscataway, N.J. 08855-1331; 908-981-0060.

The Society of Automotive Engineers (SAE) publication SP-833, *Automated Highway/Intelligent Vehicle Systems: Technology and Social Aspects*, contains 12 papers. Copies are available from SAE, 400 Commonwealth Dr., Warrendale, Pa. 15096-0001; 412-776-4841. Also available from SAE is publication P-233, *Vehicle Electronics in the 90s: Proceedings of the International Congress on Transportation Electronics*. It contains eight papers from two sessions on IVHS.

The Institute of Transportation Engineers' November 1990 *ITE Journal* is a special issue on IVHS. Copies are available from the ITE, 525 School St., S.W., Suite 410, Washington, D.C. 20024-2729; 202-554-8050.

Two IVHS conferences are scheduled this year. One is a dedicated conference on the Road Transport Informatics (RTI), Intelligent Vehicle-Highway Systems (IVHS), to be held in conjunction with the 24th International Symposium on Automotive Technology and Automation (ISATA) conference in Florence, Italy, May 20-24. Contact ISATA Secretariat, 42 Lloyd Park Ave., Croydon CR0 5SB, England; (44+81) 686 1329. The other is the IEEE Vehicular Technology Society's Vehicle Navigation and Information Systems '91 (UNIS '91), Dearborn, Mich., Oct. 20-23. Contact Mark K. Krage, GM Research Laboratories, Department 18, 30500 Mound Rd., Warren, Mich. 48090-9057; 313-986-2976.

The University of Michigan gives courses and seminars on IVHS. The next is scheduled July 29-31. The fee is \$685. To register, call 313-764-8490.

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The *Intelligent Highway* is published 11 months a year for \$345. Contact Robert French, 3815 Lisbon St., Suite 201, Fort Worth, Texas 76107; 817-731-2711.

Membership in IVHS America is open to public and private organizations and groups from any country in the world. For information on joining and on available literature, contact IVHS America, 1776 Massachusetts Ave., N.W., Washington, D.C. 20036-1993; 202-857-1202.

Incredible shrinking computers

Redesign of systems and components let engineers create desktop-power notebook computers weighing under 8 pounds



Some years back the wonder was a laptop computer no larger or heavier than a portable typewriter. But today you can choose from dozens of computers the size of standard three-ring notebook (8-1/2 by 11

inches in the United States, or A4 paper at 210 by 300 millimeters elsewhere in the world).

By now, the size of these notebook computers is limited not by engineering but by ergonomics—the need for a keyboard to feel comfortable to adult human hands and for a monitor screen to be legible at viewing distance. Capability is no problem. Today some users are buying a notebook computer instead of a desktop model for their main machine. But prices remain steep, running as high as US \$3000 to \$6000.

At the high end, the notebooks are fitted with an Intel 80386 or 80386SX microprocessor, 1M or 2M bytes of RAM, hard drive storing up to 60 Mbytes, video graphics array (VGA) flat-panel display, and perhaps a floppy-disk drive and a 2400-bit-per-second modem. All this—including batteries lasting a minimum of 2 to 3 hours on one charge—weighs in at under 8 lb (3.6 kg). The next generation of full-function handheld, palmtop and pen-based computers, which should hit their stride over the next few years, is designed to be lighter than 1 kg. (The existing handheld computers under 1 kg—such as the Portfolio by Atari Corp., Sunnyvale, Calif., and the Poquet PC by Poquet Computer Corp., also in Sunnyvale—do not yet quite offer desktop-computer power or memory, but they are getting there very fast.)

Packing all this functionality into such a small, light package has been no mean engineering feat, requiring a complete rethinking of the system. Since notebook computers are meant to be carried, such delicate components as the hard-disk drive have had to be redesigned to endure bangs and rattling

Trudy E. Bell Senior Editor

their desktop cousins never run into. For the batteries to last hours at a time, lower-power CMOS circuitry is partnered by displays and disk drives that incorporate heroic power-management techniques.

CLEAN SHEET. “We did a bottoms-up design, starting with a clean sheet of paper,” said Christopher J. Gintz, director of technology planning and development at Compaq Computer Corp. in Houston, Texas. Introduced in late 1989, Compaq’s LTE notebooks with an 8086 or a 286 microprocessor were two of the first notebook computers on the market (the first was the 4-lb NEC Ultralite in October 1988). Gintz headed the product conceptualization team for the Compaq LTE family of notebooks.

“The original concept was to make a computer that would be the size of an engineering notebook, which meant the only dimension we had to work with was the height,” Gintz said. The design goal was 8-1/2 by 11

‘We take our computer, lift it 18 inches off a concrete floor, and drop it’

by 2 inches (215 by 280 by 50 mm); they achieved 215 by 280 by 48 mm.

That 50-mm height meant clamping down on the thickness of the components inside the computer, since the keyboard and display had to squeeze in as well [Fig. 1]. That required designing some application-specific IC (ASIC) gate arrays and physically shrinking the electronics to fit on the motherboard. Moreover, the motherboard itself had to be made smaller while retaining maximum surface area.

Compaq’s solution for its LTE 386s/20 notebook computer, introduced last October, was to surface-mount the main 20-MHz 386SX microprocessor and other key chips on both sides of a motherboard using a technology called Regal Flex (Regal stands for rigid epoxy glass acrylic laminate). Regal Flex embeds both rigid and flexible materials in one continuous sheet and was developed by Teledyne Electro-Mechanisms, Hudson, N.H., for cruise missile guidance

systems and stealth fighter instrument panels. A 215-by-280-mm Regal Flex circuit board folds into a compact, multilevel part that ends up 120 by 150 by 40 mm, eliminating most cables and connectors [Fig. 2].

To keep things light, Compaq also broke with the tradition of bolting hard drive, floppy drive, and all the other components into a pre-existing frame. Instead, Gintz explained, the case of each component was attached to its neighbor’s so that the components themselves formed the computer’s structural members.

The clean-sheet exercise also revealed that notebook computers must satisfy some design criteria that are irrelevant for desktop machines. For example, since a notebook computer is to be portable, the weight of the components has to be evenly distributed so the machine would feel evenly balanced on a lap or in a briefcase. That meant making sure that the hard drive on one side was balanced by as heavy a floppy-disk drive on the other, said Compaq’s Gintz. Thus, in the arrangement of the components, weight distribution took precedence over electronic considerations such as wiring.

Other manufacturers taking the clean-sheet approach, such as Sharp Electronics Corp., Mahwah, N.J., and CompuAdd Corp., Austin, Texas, decided a floppy drive may not even be necessary, but included a set of cables and software for transferring programs and to and from a desktop machine.

Defining terms

Areal density: the density of magnetic storage on a hard drive, defined as the number of bits per inch times the number of tracks per inch.

Contact-start-stop (CSS) hard-disk drive: a hard-disk drive in which the read/write head rests on the magnetic media of the platter when the drive is off; when the drive starts, the head drags over the media until laminar air flow is great enough to generate an air bearing and support the head above the spinning disk.

Dynamic loading: a technique used in a hard-disk drive in which the read/write head rests on a ramp off the disk when the drive is off; reminiscent of a common record player, the head moves over the disk only when the disk is spinning at full speed.

Form factor: strictly speaking, the volume of a hard-disk drive, although in common parlance the unit cited is the diameter of the hard disk or platter.

Stiction: the adhesion of the read/write head to the ultrasmooth media of a hard disk by high humidity, molecular attraction, or contamination.

At many manufacturers, even the notebook computer's high-impact plastic case came in for engineering strategy, said Lee Watkins, director of hardware development at GRiD Systems Corp., in Fremont, Calif. "We needed to design a case that was lightweight and rigid without being flimsy," he said.

The GRiD engineers found that the surface area of the computer was a major influence on the case's weight. In fact, even at the light weight of 0.1 ounce per square inch (0.4 gram per square centimeter), the plastic used by GRiD weighs about 240 grams for each of the two 215-by-280-mm walls in the computer. Thus, for their 3-kg notebook, the case is about fifth the weight of the entire machine. The GRiD engineers thus experimented with eliminating unnecessary walls in the plastic-injected moldings, and shrinking the computer's footprint rather than its height.

SUM OF THE PARTS. "Components are what made this possible, no doubt about it," declared GRiD's Watkins. GRiD introduced a 5.4-kg 8086-based laptop computer at Comdex in early 1982, and has held the basic design patent for the laptop computer since 1980 (among other features, the patent covers the display folding down to cover the keyboard for carrying). But it was not until 1986 that components had shrunk enough to make a laptop computer truly practical. GRiD now has several 286- and 386SX-based notebook computers on the market.

Of all the components, the hard-disk drive was arguably the most important in letting notebook computers take their place alongside desktop models. In the late 1980s, the smallest hard drive on the market had a disk approximately 3-1/2-inch (95-mm) in diameter, was 1 inch (25 mm) high, weighed 1 lb (0.45 kg), and offered up to 40 Mbytes of storage. While that was satisfactory for 5.5-7-kg laptops, it was too bulky and heavy for a notebook.

"We went to Conner [Conner Peripherals Inc., Longmont, Colo.] with the idea that we needed a 3-1/2-inch hard drive only 3/4 inch high," Compaq's Gintz said. "They designed a drive meeting our requirements in nine months," which measured 5.15 by 4.00 by 0.75 inch (131 by 102 by 191 mm) with a capacity of 40 Mbytes. The form factor for later generations was 2-1/2 inch, with a disk measuring 65 mm. (When storage density doubles, the area on the platter needed for the same amount of storage is cut in half, and the area of a 2-1/2-inch disk is about half that of a 3-1/2-inch disk.)

Most notebook computers introduced so far include 20- to 60-Mbyte 2-1/2-inch hard drives, although 80-Mbyte drives are expected by the end of this year, said James Porter, president of Disk/Trend Inc., a Mountain View, Calif., market research firm specializing in the disk drive industry. "You can expect IBM to announce a 2-1/2-inch drive with 120 Mbytes this year," he added.

"Making a smaller drive is not simply a

problem of miniaturizing a larger drive," said Alan Kronisch, Conner's director of engineering who had coordinated the design groups. "There are a lot of parts you just can't shrink, and there are a lot of tradeoffs." For example, the areal storage density—defined as bits per inch times tracks per inch—on the 2-1/2-inch platter was higher than it was on the 3-1/2-inch platter; thus, tolerances on the height of the head flying above the disk as well as the servo tracking performance had to be much tighter, from 9 microinches to about 5 μ in. (The microinch is the unit used by the disk-drive industry and is equal to 0.025 micrometer. "American standards are so predominant in the disk-drive industry," explained Disk/Trend's Porter, "that the inch is the measurement universally preferred for disk drive dimensions, even in metric countries.")

The hard-disk drive was vital in letting notebook computers rank with desktop models

"We strove not only for miniaturization, but also simplification, to make the new drive cost-effective to build," Kronisch said, continuing a general industry trend. "We replaced mechanical parts with electronic circuits, and electronic circuits with software whenever we could" to reduce the number of moving parts.

The company designed "a lot of the testability into the drive itself," Kronisch said, so the drive could test itself after assembly instead of requiring a technician with elaborate test equipment. Whereas older drives had separate cable connections from its circuit board to the head assembly, spindle motor, actuator motor, and latch, the new drive had one flexible connection between the disk assembly and the circuit board.

LOADED QUESTION. PrairieTek Corp., Longmont, Colo., which invented the first 2-1/2-inch drive, included some similar changes. But its biggest innovation was a "technique for unloading the heads off the media while the platter spun down," said Steven Volk, former PrairieTek vice president of sales and marketing who is now president and chief executive officer of Integral Peripherals Inc., Boulder, Colo., a company founded late last year to develop a 1.8-inch drive (with a 48-mm disk) for the next generation of handheld palmtop computers.

In all hard drives, the read/write head flies a few microinches above the magnetic stor-

age media, kept aloft by the laminar flow of air over the spinning platter. The spring-loaded head is under just enough tension to keep it at a constant height above the platter.

The traditional drive in present-day desktop and laptop computers—such as those by Conner Peripherals and Quantum Group, Milpitas, Calif.—are known as contact-start-stop (CSS) drives: when the drive is shut down (when, say, the computer is turned off or during the numerous power-down cycles to conserve the battery), the platter stops spinning and the head comes to rest directly on the media in a special "landing zone" close to the platter's spindle [Fig. 3]. When the drive is started, the head drags on the media until the platter is spinning fast enough for the laminar air flow to be great enough for the head to become airborne. That start-up time takes 5 to 7 seconds. Up to about 1000 revolutions per minute, the head is dragged, for a total of about 6 meters; up to about 2000 rpm, it begins bouncing; and only between 2000 and 3000 rpm does it begin flying.

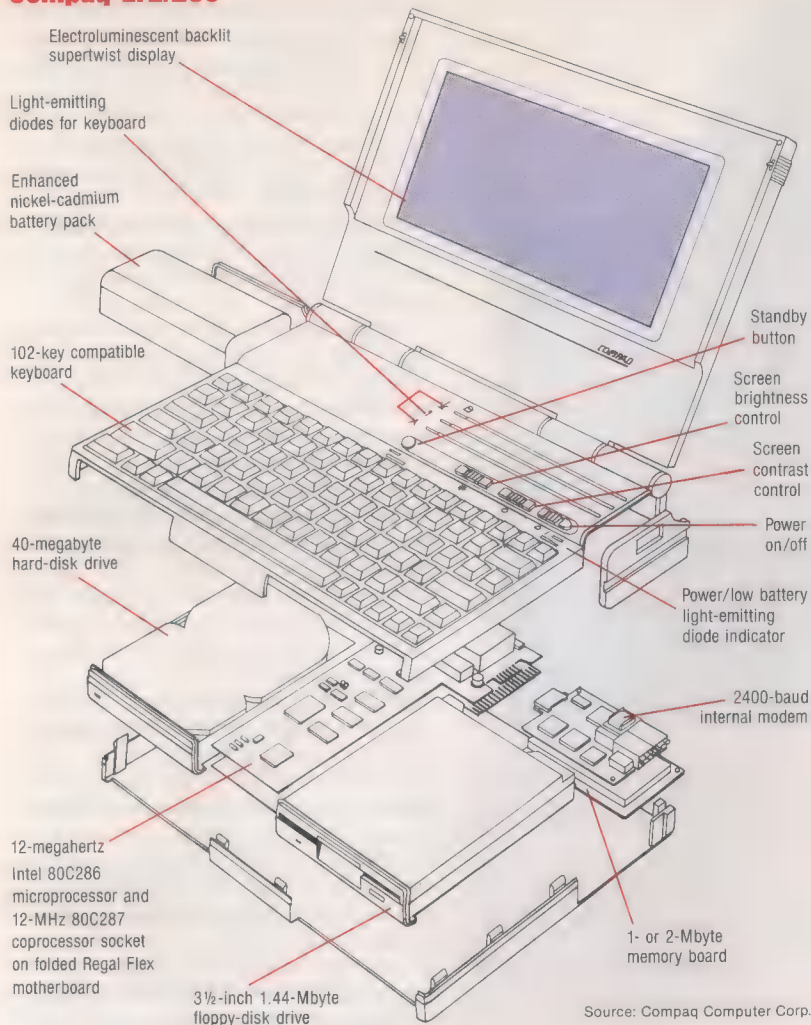
"That's very hard on the drive," Volk said. "You can typically do that only about 20 000 to 30 000 times before you degrade the heads and the media" with particles gouged out of the media by the dragging or bouncing head. PrairieTek designed a drive using a technique called dynamic loading: as in a record player, the platter has to be spinning at full speed before the head leaves a storage ramp off to the side and moves over the disk [Fig. 4]. "With dynamic loading, the heads never come in contact with the media," so there is no wear, Volk explained, allowing a mean of more than half a million start-stops.

Dynamic loading is an old idea, used in essentially all disk drives from IBM Corp.'s 14-inch RMAC drive in 1954 through the early 1970s. About that time IBM introduced Winchester disk technology, which featured the first contact-start-stop drive. Other manufacturers copied the IBM technology, although not without some difficulty. Dynamic loading of Winchester-style heads was originally thought not to be a stable process, and some people continued with that belief.

STICKING POINT. Dynamic loading further improves the reliability of the hard drives in notebook computers by eliminating "stiction, or frozen drive syndrome," a predominant failure mode in contact-start-stop drives, said PrairieTek's vice president of research and development, Ken Jochim.

As areal storage density of magnetic media increases, read-write heads must fly ever closer to the disk surface—now to within 1 μ in. That means the surface of both the media and the heads must be ever smoother—smooth to below 1 μ in. When two surfaces are so highly polished, however, molecular attraction, contaminants, or extraneous lubricants cause the head to stick to the media. To minimize stiction in a CSS drive, the media surface is scored "to give it a microtexture," Jochim said.

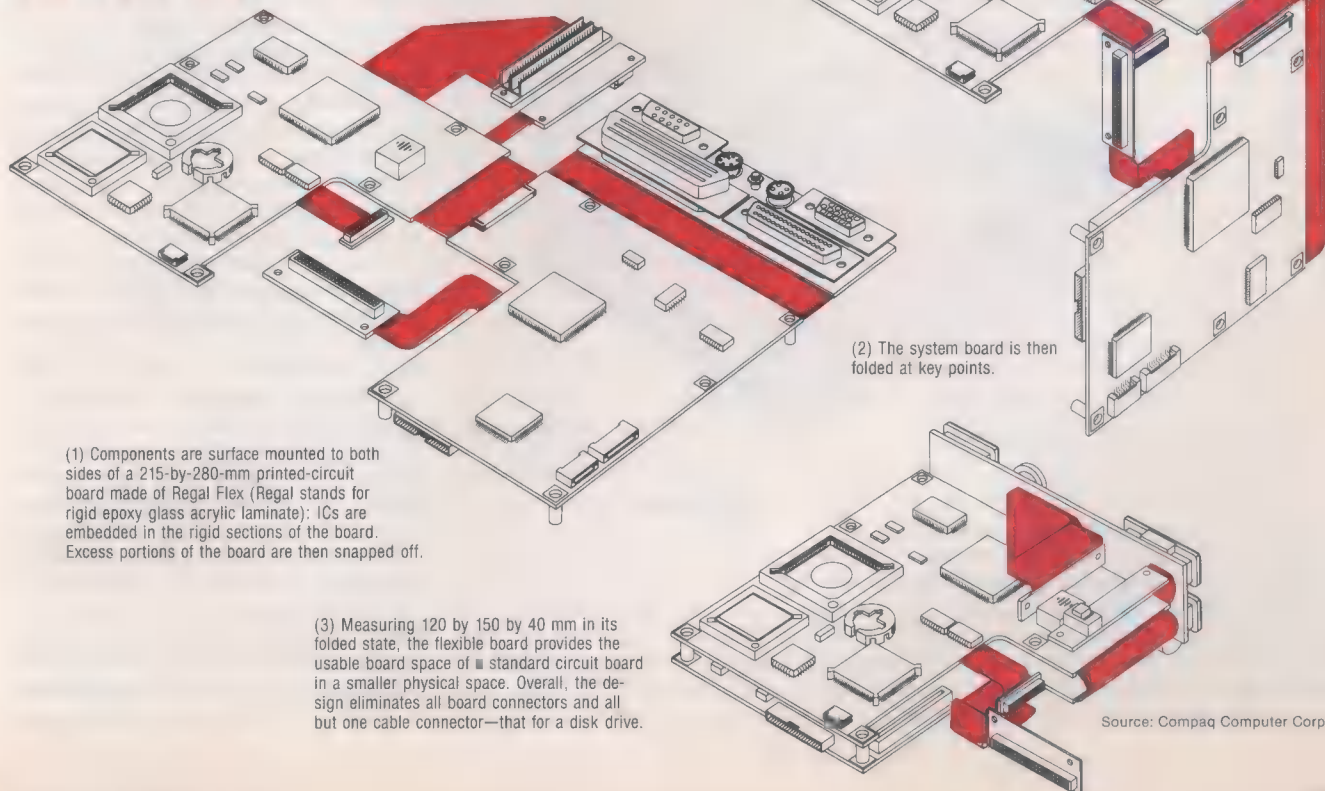
Compaq LTE/286

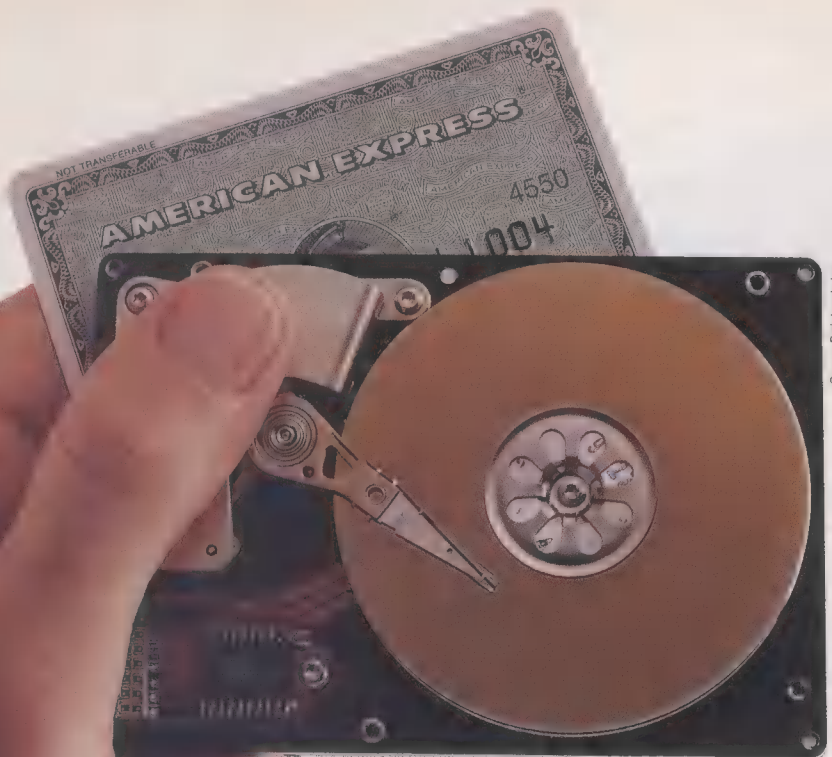


[1] This exploded view of the LTE/286, built by Compaq Computer Corp., Houston, Texas, shows how the components of a desktop-power Intel-80286-based computer were shrunk and precisely fit into a package the size of a three-ring engineering notebook and weighing under 8 pounds (3.6 kilograms).

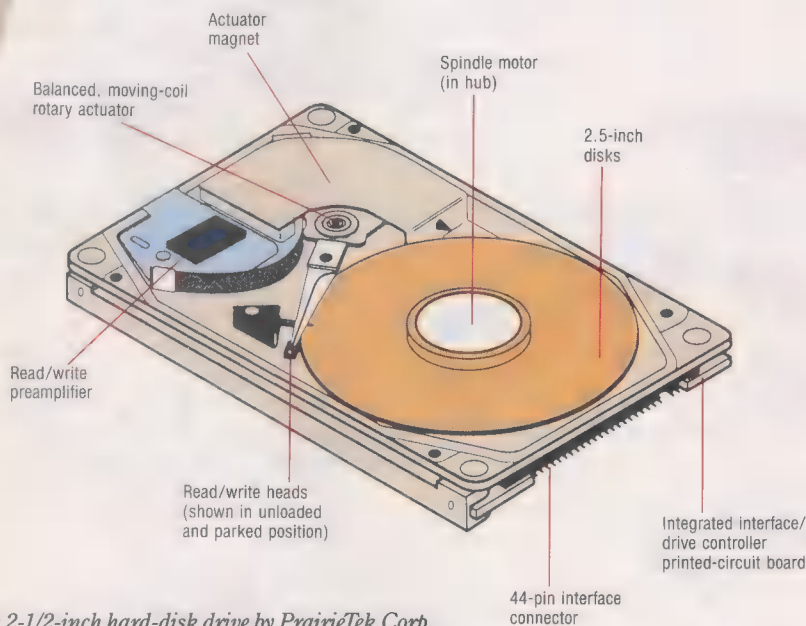
[2] A motherboard that folds is key to the packaging of many components in Compaq's latest LTE 386s/20 notebook computer.

Regal Flex Circuit Board





[3] The 2-1/2-inch hard-disk drive by Conner Peripherals Inc., Longmont, Colo., is the one most widely used in today's notebook computers. It is a contact-start-stop (CSS) drive, meaning that the read/write head rests on the magnetic media of the platter near the center of the disk when the drive is off, as shown. When the drive starts, the head drags on the media until laminar air flow is great enough to keep it airborne above the spinning disk.



[4] The 2-1/2-inch hard-disk drive by PrairieTek Corp., Longmont, Colo.—which invented the first drive of that size—uses a technique called dynamic loading to keep the read/write head from ever touching the magnetic media. The head instead rests on a ramp at the edge of the disk when the drive is off, as shown. Reminiscent of a common record player, the head moves over the disk only when the disk is spinning at full speed.

Source: PrairieTek Corp.

In ■ CSS drive, the usual way of overcoming stiction is to give the motor enough torque to pull the head loose from the media. At the least, that requires momentarily high power—up to 5 watts. At the worst the head slider can be pulled off its suspension, or the motor may not have adequate torque to break loose the head and spin up the disk—either case being a failure of the drive. “With dynamic loading, stiction is designed out,” Jochim said. “You can optimize the head and media surfaces for recording, not stiction.”

For notebook computers, the elimination of stiction is crucial because the power management systems may be switching the hard drive off and on dozens to hundreds of times a day. “For a desktop computer that is not turned off all day, 30 000 to 40 000 starts and stops for a CSS drive may be adequate,” Jochim said, but that figure could be reached in a year or two in ■ notebook computer in daily use.

At least one of PrairieTek's competitors—Seagate Technology Inc., Scotts Valley, Calif.—is investigating dynamic loading for its own hard drives.

THIN DISPLAYS. For the most part, the lightweight flat-panel liquid-crystal displays (LCDs) common in heavier laptop computers have also found their way into the smaller notebooks. Some have twisted-nematic crystals to heighten their contrast and fluorescent backlighting or sidelighting to brighten the image [see *IEEE Spectrum's* three articles on flat-panel displays, September 1989, pp. 34–45].

Typically the displays consist of two sheets of glass with a few milliliters of liquid-crystal material between them; electrodes from ■ printed-circuit board behind the display are affixed to the rear glass panel. An electric field on any one of the electrodes turns on or off a pixel on the screen.

The GRiD notebook computers, however, incorporate the uniquely lightweight chip-on-glass display offered only by Kyocera Corp. of Kyoto, Japan, said GRiD's Watkins. In that display, the rear glass panel itself functions also as the circuit board; ICs are mounted directly to the glass and wirebonded to traces on the glass.

GRiD and other notebook-computer manufacturers are using the more recent tape automated bonding (TAB) technology, in which ICs are mounted to a flexible circuit board made of Mylar, Kapton, or some other polymer instead of a traditional fiber circuit board. They are also moving to thinner glass. Moreover, drivers are getting faster because of both higher clock rates and higher pin counts (more drivers per package).

The heaviest single element of all the notebook computers is the batteries, amounting to up to ■ third of the total weight. Most notebook computers use advanced nickel-cadmium rechargeable batteries that last for two or three hours between charges—30 to 40 percent longer than stan-

dard NiCd batteries of the same size and shape, said Joseph Carcone, vice president of marketing and sales of Sanyo Energy U.S.A. Corp., in San Diego, Calif. According to Carcone, Sanyo makes the batteries for about 80 percent of the notebook computers on the market, including all those by Compaq, GRiD, and Zenith.

The advanced NiCd batteries pack more power because of changes in their internal construction: thin-wall casing, new designs for both electrodes, thinner separator material, and a more active electrolyte, Carcone said. In addition, some notebook manufacturers, such as Sharp, designed their computers to use a rectangular battery rather than a cylindrical one, because the rectangular one has greater volumetric energy density than a cylindrical cell of the same outside diameter.

POWER MISER. A new battery technology, first introduced commercially last November in a notebook computer offered by Toshiba Corp., is rechargeable nickel-metal hydride. "It has about 30 percent more energy density than even the advanced NiCd battery in the same volumetric space," Carcone said, with roughly the same cycle and life characteristics. Although Sanyo is the only company now making them in commercial quantities, the new battery will soon be offered by Gates Energy Products, Ovonic, and Panasonic, he said.

"As a rule of thumb, you can get 15-20 watthours of energy for every pound of battery," said GRiD's Watkins. Primary (non-rechargeable) manganese dioxide or alkaline cells give about twice that energy, but are no lighter—and are more expensive as they must be replaced after one discharge.

To shrink the batteries' weight while extending their life, engineers minimize the power drawn by the computer's components. All notebook manufacturers program their displays to shut off if the keyboard has not been used for a minute or two. Chip vendors have helped design low-power chip sets, and CMOS technology reduces power consumed in the dynamic RAM. Static RAM, basically an array of flip-flops, would require even less power, but is still too expensive a technology to be commercially practical, Watkins said. Also, GRiD was a pioneer in memory management circuitry, which allows the computer's microprocessor to shut down while saving its state when it has not been used for a minute or so.

Connor and PrairieTek were two of the first companies to design a disk drive with power management software, which reduces the drive's average operating power from 15 watts to less than 1 W. Today all 2-1/2-inch drives have four power states: active, when the drive is actually reading or writing; idle, where the disk is spinning and it is ready to read or write; standby, where the disk has stopped spinning (usually when the drive has not been used for a minute or so); and sleep, where the microprocessor and clock chips are also turned off.

Any of the low-power states are exited when the computer sends the drive a command. While the standby state did exist in laptop computers, the earlier versions of DOS (disk operating system), which is used in all the IBM clones, did not support the sleep state until the birth of the notebook computers. The difference that power management makes is indicated by the fact that in at least one drive, PrairieTek's, the standby state consumes only 50 milliwatts—and "since the drive spends most of its time in standby, that value is critical since it dominates total power usage," Jochim said.

Dynamic loading helps conserve even more power, he added. Drives with dynamic loading take 1-2 seconds to spin up from sleep mode versus the 5-7 seconds required for the CSS drives. Moreover, the CSS drives require two to four times as much energy from the batteries to overcome the normal friction of the head dragging on the media, plus longer time to spin up the disk.

To extend the batteries' life, engineers wrote heroic power management software for the components

The new 2-1/2-inch disk drives are the first to operate on only the 5 volts from the batteries, said Intégral's Volk. Until notebook computers came along, disk drives in laptops and other portables were designed to function at 5 and 12 V because they could also be plugged into regular line voltage. Optimizing the notebooks for just the one battery voltage increases efficiency, because it eliminates the power lost in stepping up the battery voltage to 12 V.

To further extend battery life, "systems manufacturers now want us to design hard drives that will tolerate ± 10 percent of the nominal voltage," Volk said. Current drives typically can handle ± 5 percent, so as the batteries run down, the drive will operate down to 4.75 V. "Eventually we want to get down to the 3-V range so a computer can use fewer battery cells," Volk added, a task he estimated would take another two or three years to engineer.

SHOCK TREATMENT. "We take our computer, lift it 18 inches [45 centimeters] off a concrete floor, and drop it," said Compaq's Gintz. Since a briefcase carrying the computer might easily fall over onto its side even in normal use, or even drop from desk to floor, engineers have put great effort into

designing the computers to withstand levels of nonoperational shock and vibration never suffered by their desktop cousins.

For a CSS drive, that level of protection is 75-100 gravities of acceleration, said PrairieTek's Jochim. It is upwards of 150 g for a drive with dynamic loading, and has been tested to as high as 300-400 g, he noted. Although in a CSS drive the air bearing protects the head from hitting the disk during operation, when the drive is turned off the head is free to spring off the disk's landing zone and bounce back down to hit the magnetic media. With dynamic loading, Jochim said, when the head is not in use, it is anchored to the storage ramp off the disk.

Although drives are resistant to disk damage from shock during operation, a side-to-side shock as small as 10 g can induce the head to write on the track adjacent to the correct one. "This is the weak spot of all disk drives," Jochim remarked.

One form of shock unique to the smallest notebook computers and the palmtops is rotary shock. "It's rare you pick up a desktop computer and twist it around," observed Intégral's Volk, "but with a notebook or handheld computer you can hold it in one arm or hand, walk around, punch numbers, and turn from here to there." The centrifugal force can relocate the head so that it will write to or read from some random location. Volk's team at Intégral is working on the proprietary design of a high-bandwidth servo system that will keep the drive on track.

TO PROBE FURTHER. Many of the computer trade publications have featured articles on specific notebook computers. *PC Magazine* had omnibus reviews of several dozen 286-based and 8086-based notebooks in its March 12, 1991, issue, pp. 225-277. *Byte* focused on notebooks in its product evaluation "Perfectly Portable," pp. 148-162, February 1991; that issue also included a special report on laptop technologies, pp. 200-264, with much of relevance to notebooks.

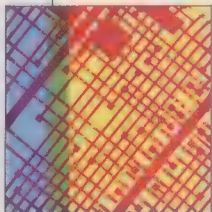
The monthly magazine *PC Laptop Computers* focuses solely on technical developments and product announcements in the world of notebook, laptop, and portable, computers; for an annual subscription, which costs US \$24.95 in the United States and \$34.95 elsewhere, write to Box 16927, North Hollywood, Calif. 91615.

The technology of flat-panel displays is detailed in three articles in the September 1989 issue of *IEEE Spectrum*: "Flat-panel displays displace large, heavy, power-hungry CRTs," by Lawrence E. Tannas Jr., pp. 34-35; "Manufacturing hurdles challenge large-LCD developers," by Gary Stix, pp. 36-40; and "How to select a flat-panel display," by Melvin F. Silverstein, pp. 41-45.

One example of the intense thought that has gone into the design of the outer case of a notebook computer is recounted in "The Yearlong Trek to AT&T's Safari [AT&T's new 80386-based 7-pound notebook]," by Bruce Nussbaum, *Business Week*, April 8, 1991, pp. 86-87. ♦

Utilities get serious about efficiency

U.S. experiments promise enormous energy savings by enabling utilities to profit as much—or more—from reduced demand



For slightly over a century, the fortunes of most electric utilities have risen and fallen with their output: when they sold more kilowatt-hours, they made more profit. This simple equation has seen the industry expand steadily from a collection of struggling power producers to the custodian of a ubiquitous, essential infrastructure.

But increasingly, the paradigm poorly serves densely populated regions in industrialized nations, where for social and political reasons power plants are now more costly or even impossible to build. From an environmental viewpoint, the scenario is even less attractive, assuming that the United States and other countries continue to rely heavily on fossil fuels, as current strategies suggest they will.

More kilowatt-hours mean more tons of carbon dioxide, sulfur dioxide, and nitrogen oxides in the atmosphere—in short, more environmental degradation, recent studies suggest.

In bold experiments aimed at bringing utility-financial models more in line with these realities, U.S. utilities and state officials in California, New York, and New England have adopted regulations enabling utilities to profit as much—or more—by convincing their customers to cut their electricity use by relying on more technologically advanced, energy-efficient lighting, equipment, and appliances. Though ignored in President Bush's recently promulgated National Energy Strategy, favorable results could herald major changes in the role utilities play in their communities and in the way they invest in new resources.

"Utilities tend to see their business as running big machines and selling electrons," said Henry Kelly, senior associate at the congressional Office of Technology Assessment in Washington, D.C. "But soon services like design assistance and energy consulting will be a major part of their business. It's a very

Glenn Zorpette Senior Associate Editor

fundamental change we're talking about."

The potential energy savings are staggering, according to the Electric Power Research Institute (EPRI). The Palo Alto, Calif.-based organization estimates that state regulations and market mechanisms will result in energy-use reductions of about 8.5 percent by the year 2000. Utility efficiency programs could account for another 3 percent, trimming summer demand by 45 gigawatts (about 6.7 percent)—saving an estimated US \$45 billion by the turn of the century.

Such numbers merely scratch the surface of what is believed technically possible if complete market saturation could be achieved with the most efficient electric technologies available today. Under these conditions, energy savings could reach 24 to 44 percent *beyond* the expected 8.5 percent, EPRI believes.

The underlying concepts are not entirely new. As the costs of new plants rose sharply in the 1980s, many utilities found it more cost-effective in certain cases to defer new construction by, among other things, encouraging customers to use less electricity

It's like
telling Pepsi,
'sell less soda pop'

during peak periods. However, little was spent to promote this conservation and it was viewed for the most part ■ ■ ■ temporary or intermittent measure—to reduce loads during the summer months, for example.

The programs in California and in the northeastern United States, on the other hand, seek to make conservation a realistic, permanent alternative to construction of new generating facilities. The critical ingredient in all three areas is a set of complex regulations by state public utility commissions that make conservation—through the use of more energy-efficient equipment, lighting, and appliances, for instance—at least as attractive financially as construction, not only to the utility but to its ratepayers as well.

"It's counter-intuitive," concedes Christopher C. Finkle, senior marketing coordinator at Niagara Mohawk Power Corp.

in Syracuse, N.Y. "It's like telling Pepsi, 'sell less soda pop.' But the numbers are there, and they're very compelling."

PG&E IN THE LEAD. After evolving over the last few years, these regulations have been in effect for about a year. In all three regions, utilities are pursuing conservation with varying degrees of intensity, but perhaps none quite as vigorously as San Francisco, Calif.-based Pacific Gas & Electric (PG&E) Co. The utility, the eighth largest in the United States in kilowatt-hour sales, recently began a five-year, multimillion-dollar program devoted to energy efficiency and is pushing conservation to the exclusion of three-fourths of its anticipated near-future capacity growth.

"PG&E is one of the very few utilities that recognizes it is on the verge of becoming a very different company," Kelley said.

What made the PG&E program possible was an agreement reached last August between California's Public Utilities Commission (PUC) and the state's utilities. Under the terms of this agreement, or "collaborative" as it is known in the state, utilities are entitled to 15 percent of the net benefits produced by their conservation programs (their ratepayers receive the other 85 percent). The net benefits are defined as the utility's monetary savings accrued by generating, transmitting, and distributing less electricity (by purchasing less fuel, for example), *minus* what it cost the utility to bring about the savings (the costs of rebates to customers who buy more efficient appliances, for example, and money spent on promotional campaigns for the programs).

The net benefits could be substantial, in both monetary and environmental terms. According to PG&E spokesman Paul Ward, the company estimates that it costs about 3-4 cents to save a kilowatt-hour—about half as much as it now costs to generate one with ■ gas-fired plant, on average, over the life of the plant. PG&E expects peak demand to grow by 3300 MW by the end of the decade, but the company hopes to reduce that growth by 2500 MW through its efficiency programs, while preventing about 5490 metric tons of sulfur dioxide, 24 300 tons of nitrogen oxides, and 16.3 million tons of carbon dioxide from entering the atmosphere.

The total net benefit is estimated to be about \$200 million for this year alone. The 10-year time frame was chosen partly because PG&E anticipates the availability of

cleaner-burning generation technologies by the year 2000.

In 1990, the first year of its "Reducing Plan," Niagara Mohawk spent about \$20 million and saw energy savings of 110 000 megawatt-hours, according to Finkle. The utility also shaved almost 30 MW off its summer peak of about 6700 MW, and nearly 29 MW off its winter peak, which is comparable in magnitude to the summer one.

This year, New England Electric System plans to spend \$85 million, or 5 percent of its total revenues, on its conservation and load management programs, according to Mark Hutchinson, an analyst in the Westborough, Mass., company's demand planning department.

California had a head start in this area because its utilities were already operating under a rate structure that decouples revenue from kilowatt-hour sales. Under their Electric Revenue Adjustment Mechanism (ERAM), utilities and the PUC agree on a forecast of the utility's energy sales for the coming year, along with revenue requirements needed to meet those sales. Dividing the second quantity by the first determines the rate the utility can charge for the coming year. If the utility sells less energy and thus makes less money than it had forecast—because of conservation, for example—it can recoup the difference the next year. ERAM is a double edged-sword, however: if the utility sells more than it had forecast, it owes the difference to its ratepayers.

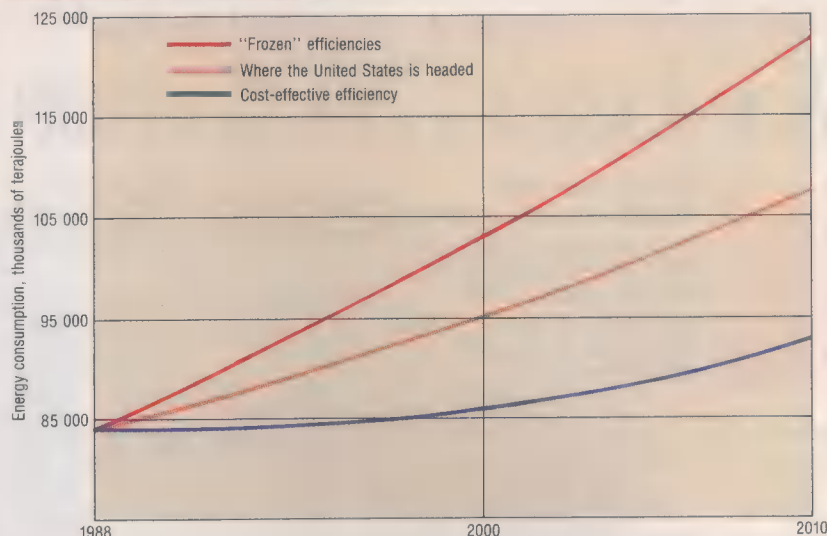
LITTLE LAMPS, BIG REBATES. Encompassing residential, commercial, and industrial usage, PG&E's Customer Energy Efficiency program is similar to other utility programs in California and the Northeast. One important component of the residential programs is encouraging customers to replace incandescent lighting with efficient fluorescents. PG&E, Niagara Mohawk, New England Electric System, and other utilities are heavily promoting recently developed compact fluorescent lights. An 18-watt fluorescent provides as much light as a 75-W incandescent, and lasts five to 10 times as long. PG&E offsets the \$12 price of a fluorescent light by paying a rebate of \$7.

According to EPRI, lighting now accounts for 15-20 percent of all electricity used in the United States. In the residential sector alone, electricity used for lighting could be cut by almost 75 percent by the year 2000 if only the most efficient lighting technologies were used throughout the country, EPRI estimates.

PG&E and other utilities also offer rebates for household appliances, some of which are now twice as efficient as their predecessors of only 15-20 years ago (today's most efficient refrigerators, for example, use only about half as much electricity as comparable models from the 1970s).

Many efficiency programs for commercial and industrial customers also emphasize lighting. About three-fourths of energy sav-

Projected U.S. energy use



Source: U.S. Department of Energy, Oak Ridge National Laboratory

ings produced by the New England Electric's Energy Initiative Program have come from more efficient lighting, according to Hutchinson. The company is also encouraging commercial and industrial users to install more efficient motors, variable-speed drives, and refrigeration and cooling systems.

Many utilities are also offering customized programs that enable these larger customers to come up with their own energy-saving schemes and bargain with the utility for rebates, technical assistance, and other inducements. Some utilities also offer free "walk-throughs" at the homes of residential customers, during which a trained expert assesses the customer's appliances, heating and cooling equipment, insulation, and energy-usage patterns to suggest improvements.

BETTER BUILDINGS. Utility officials contacted by *IEEE Spectrum* agreed that new buildings offer tantalizingly large potential energy savings for several reasons. Efficiency measures built into a building generally last the life of the building—typically 50 years or more—and if not installed at the outset, "are often permanently deferred," noted Thayone Jones, senior engineer with Southern California Edison Co. in Rosemead. Also, the costs are much less if better insulation, more efficient appliances and equipment, and even sensors to monitor and control energy use are installed as the building goes up.

While such programs will encourage the use of high-efficiency appliances in certain areas, Federal standards that could make a national impact are finally on the way.

At present, there are standards for furnaces, water heaters, refrigerators, freezers, room air conditioners, and fluorescent-light ballasts. Standards for central air conditioners and heat pumps are to go into effect in 1992. In 1993, there will be standards for

dishwashers and clothes dryers and washers, and an update of the refrigerator and freezer standards.

Although advocates of energy efficiency welcome the new standards, they were bitterly disappointed by the President's National Energy Strategy. A draft of the strategy that was leaked to the press on Feb. 8 created a stir because it was widely perceived as overlooking efficiency. This draft suggested only three modest efficiency measures: requiring standards for electric lights and their labels; authorizing loans from the U.S. Treasury for efficiency improvements at Government offices; and removing taxes from the rebates offered by utilities to customers who install high-efficiency lighting and appliances (at present, only the first \$600 of rebate income is tax free).

Not even these three survived final review by presidential advisors; the final strategy, as released on Feb. 20, omitted or seriously weakened all of them, reportedly at the insistence of White House Chief of Staff John Sununu. The Federal appliance standards, first proposed during the Carter administration, were challenged by the Reagan administration, only to be upheld after a legal struggle that lasted nearly a decade.

"We would like to see more done on a national level," said the New England Electric's Hutchinson. "We feel there are a lot of lost opportunities out there now."

TO PROBE FURTHER. "New Push for Energy Efficiency" was published in the April/May 1990 *EPRI Journal*, the monthly publication of the Electric Power Research Institute. The institute's headquarters are at 3412 Hillview Ave., Palo Alto, Calif. 94303; 415-855-2000. In its December 1990 edition, *The Electricity Journal*, with editorial offices in Seattle, Wash., published "Making Conservation Pay: The NEES Experience" by John W. Rowe, president of the New England Electric System.

Wanlass's CMOS circuit

For the record

June 18, 1963: Frank Wanlass applies for a patent on complementary field-effect transistor circuitry that reduces the standby power consumption of digital logic by six orders of magnitude

Most people remember the '60s as the era of the Beatles, the Vietnam War, Woodstock, and 35-cent-a-gallon gasoline. But electronics engineers of a certain age remember them as the days of free-wheeling experimentation when—at some companies, at least—bright young Ph.D.s were given latitude to see what they could create without interference from corporate managers.

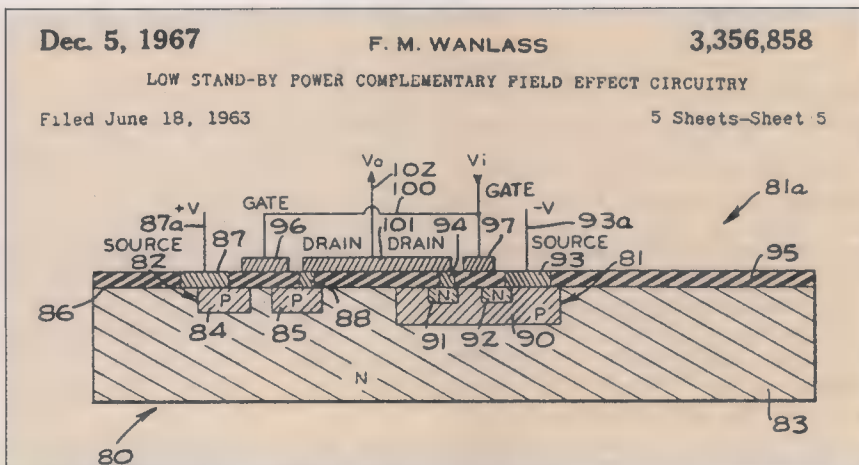
One bright young Ph.D. of that time was Frank Wanlass, who this February received the 1991 IEEE Solid-State Circuits Award for his invention of complementary-MOS (CMOS) logic circuitry.

Wanlass's interest in MOS technology dates to 1962, when he was still studying for his doctorate in solid-state physics at the University of Utah in Salt Lake City. Upon reading about the Radio Corporation of America's work with thin-film cadmium sulfide field-effect transistors (FETs), he became intrigued by the simple structure of the devices, which he thought would make it easy to design fairly complex integrated circuits. But the devices were unstable. When left on ■ shelf for just a few hours, their electrical parameters changed dramatically.

Wanlass believed that making the FETs in silicon would solve the problem. After all, Fairchild Semiconductor Research and Development had made some very stable and reliable bipolar transistors in silicon using its planar process, so why not use the same material to make stable MOSFETs?

So he went to work for the Fairchild Semiconductor subsidiary of Fairchild Camera and Instrument Co. in Palo Alto, Calif., in August 1962, unaware that other researchers were already working on silicon MOSFETs at both RCA and Bell Laboratories. A few months later, he made his first p-channel silicon MOSFETs, which, like all early MOSFETs, were a great disappointment. At 10–20 volts, their threshold voltages were very high and very unstable. They were no better than RCA's CdS devices.

Wanlass speculated that the aluminum gate electrode was diffusing into the gate oxide. If that were the case, the use of a more inert metal would solve the problem.



Wanlass's patent portrayed an integrated CMOS inverter.

While investigating that possibility, he found to his surprise that aluminum electrodes deposited by an electron beam evaporation machine yielded quite stable devices. The problem, he began to suspect, was not aluminum diffusion after all, but contamination.

The usual way to deposit aluminum in those days was to evaporate it by placing an aluminum wire in contact with a heated tungsten filament. Wanlass reasoned that the process was introducing positive ions into the aluminum and thence the gate oxide.

Further investigation incriminated sodium contamination from both the tungsten and the aluminum. Electron beam evaporation solved the problem because the electron-beam apparatus had a shutter mechanism that protected the silicon wafers from a carbon crucible of molten aluminum until the aluminum was at evaporation temperature. The sodium, having a much lower boiling point, boiled away before the shutter opened.

Wanlass next had the idea for CMOS. "It occurred to me," he told *IEEE Spectrum* in a recent interview, "that a complementary circuit of NMOS and PMOS devices, if it could be made, would use very little power. In standby, it would draw practically nothing—just the leakage current."

His boss Gordon Moore, now the chairman of Intel Corp., gave him a free hand to pursue his idea. At first, Wanlass tried to build a CMOS circuit monolithically, but that was so difficult he decided to prove the concept with discrete p-channel and n-channel MOSFETs instead. Because only p-channel devices were available, he had to start by building an n-channel silicon MOSFET.

The CMOS concept requires that both of its transistors be enhancement-mode devices. But whereas PMOS transistors were inherently of that type, the n-channel

MOSFET was not. It would be years before MOS surface physics was well enough understood to permit the fabrication of such devices. Consequently, Wanlass made depletion-mode n-channel MOSFETs and back-biased their bodies negative with respect to their sources to turn them into enhancement-mode units.

The concept worked. The first demonstration circuit, a two-transistor inverter, consumed just a few nanowatts of standby power. Equivalent bipolar and PMOS gates consumed milliwatts of power even in standby. CMOS shrank the standby power consumption by six orders of magnitude!

The speed was impressive enough, too. Propagation delay times were on the order of 100 nanoseconds—about half the speed of bipolar, but almost an order of magnitude faster than PMOS.

On June 18, 1963, Frank Wanlass applied for patent protection for his CMOS concept, and in due course, was granted U.S. patent no. 3 356 858, the rights to which became part of Fairchild's patent portfolio. That patent described the overall concept and three specific circuits—an inverter, a NOR gate, and a NAND gate—from which any digital function can be built. In addition to the discrete implementations that were actually built, the patent includes the representation of an integrated CMOS inverter shown here. (Wanlass's laboratory notebooks, with his original drawings, were lost, probably when Fairchild Semiconductor was taken over by National Semiconductor Corp. in 1987.)

Neither Wanlass nor Fairchild Semiconductor grew rich from the invention. In those days companies traded the rights to their patent portfolios. Still, the integrated CMOS inverter shown, although never built, is the progenitor of all CMOS ICs today. ♦

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Theoretical Kinematics. Bottema, O., and Roth, B., Dover Publications, New York, 1979, 558 pp., US \$12.95.

Object-Oriented Analysis. Coad, Peter, and Yourdon, Edward, Prentice-Hall, Englewood Cliffs, N.J., 1991, 233 pp., \$31.

3D Interactive Computer Graphics. Teunissen, Wim J., and van den Bos, Jan, Ellis Horwood, London, 1990, \$59.95, 229 pp.

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Internetworking with TCP/IP, Volume I, 2nd edition. Comer, Douglas E., Prentice-Hall, Englewood Cliffs, N.J., 1991, 547 pp., \$50.

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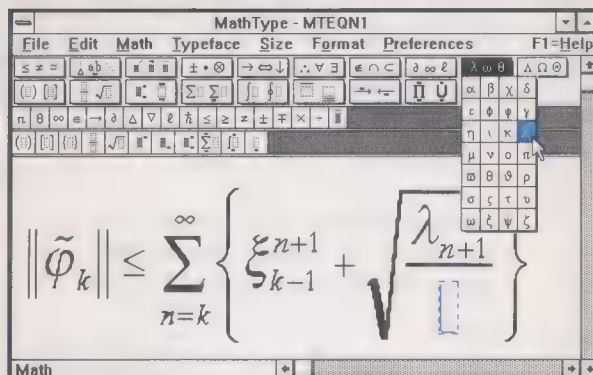
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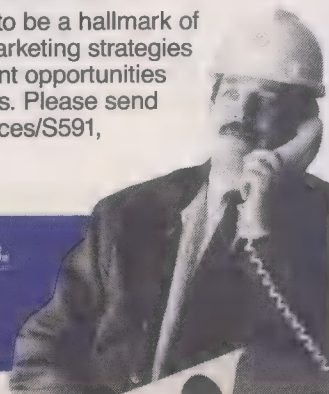
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Medtronic, Inc., the world's leading manufacturer of implantable medical products, has an exceptional opportunity for an Engineer/Scientist in our Cardiac Pacing Research Department.

This person will be responsible for modeling of advanced research concepts applicable to implantable defibrillation and pacing systems. A PhD or MS in Engineering/Physics with at least 3-5 years of experience in finite element modeling is required. Familiarity with modeling of electrical fields is desirable.

Medtronic, Inc. offers a highly competitive compensation and benefit package plus the opportunity for personal recognition in an environment where new ideas and initiative are encouraged. Please send your resume in confidence to: **Vern Brewster, MEDTRONIC, INC., 7000 Central Avenue N.E., Minneapolis, MN 55432.**

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Systems Design Engineer — In this area, you will be involved in guidance and control systems analysis and hardware/software design trade-offs. Specification designs, including guidance, navigation and control algorithm development, as well as systems integration and installation, flight test and customer liaison activity, are a part of these positions.

System Software Development — This area involves development of flight software for advanced guidance and control systems for aircraft using modular and structured programming techniques. You will be involved with algorithms and development of real-time programs in both assembly (8086 family, Z8002 and 68000) and high order languages such as Pascal, "C," Ada and PLM/86, with subsequent hardware integration.

Electronics Engineering — These positions involve the development of new processor/bus architectures and specifications

to support fault tolerant/redundant airborne applications.

Display Systems — These positions offer systems, software and hardware opportunities with CRT/LCD display technology. You should be familiar with digital hardware design and/or real-time programming. Systems functions include overall system definition, design and customer interaction.

To qualify for the positions listed above, you should have a BSEE or a BSCS degree and at least three years of experience.

Ada Software Systems Engineers — In these positions you will design, implement and maintain software tools hosted on VAX/VMS computer systems and written in Ada and "C" languages. Experience with designing and implementing compilers, linkers, debuggers and runtime libraries targeted to RISC architectures is required. A background in Ada compiler support is highly desired.

Additional opportunities are available in:

- CRT/LCD Display Technology
- Avionics Systems Simulation

- CAE Engineering (Apollo Mentor Systems)
- Artificial Intelligence
- VAX Systems Administration
- Fiber Optic Pressure Sensors
- EMI/HERF
- Software Tools Development

Make a career move. Honeywell offers you a competitive salary and benefits package. All new employees are required to successfully complete a drug screening test. Send your resume and salary history, in confidence, to Honeywell, Commercial Flight Systems Group, Professional Employment (IEEE-E904), P.O. Box 21111, M/S L-17C, Phoenix, AZ 85036.

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Digital Signal Processing

The Environmental Research Institute of Michigan (ERIM), a growing, leading-edge, research and development organization with headquarters in Ann Arbor, MI, has newly created opportunities for a select group of talented Research Engineers and Scientists for the following areas:

Systems:

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- Kalman filtering
- Motion compensation/navigation systems
- Documentation specialist
- Computer systems manager (networked SUN environment)

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- Software systems engineering/simulation/modeling
- User interfaces
- Software testability
- Ada, CASE tools, UNIX, X11, MIL-STD-2167A environment

Hardware:

- RF and microwave design, high speed digital and analog circuit design, microprocessor and interface technology, digital signal processor design.

Previous experience with U.S. Government programs desirable, as is a BS, MS or PhD in Computer Science, Electrical Engineering or Mathematics.

You'll receive an excellent salary with outstanding benefits and growth potential. For prompt consideration, please forward your resume in strict confidence to either: ERIM, Box 8618, Ann Arbor, MI 48107-8618; or ERIM, 5757 West Century Blvd., Suite 340, Los Angeles, CA 90045 - Attn: Human Resources Manager-IE/591. ERIM has recently implemented a Doctoral Fellowship Program to promote continued technology growth and development. The program, sponsored in conjunction with the University of Michigan's Department of Electrical Engineering and Computer Science (EECS), is now accepting inquiries at the above locations. An Equal Opportunity Employer. U.S. Citizenship Required.



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Analyze & develop software for modeling/simulation of autonomous underwater vehicle including vehicle dynamics, navigation and attitude sources, acoustic and optical sensors. Minimum MS in math, physics, engineering or computer science plus 3-5 years related experience preferred. Experience with signal processing, optimal estimation, graphical simulation AI and robotics preferred. Refer to Box 54PAM.

RESEARCH ASSOCIATE

Outstanding individual sought for oceanographic research and programming involving acoustic methods to sense ocean fluctuations. Firm understanding of FORTRAN or C and spectral estimation required. Familiarity with statistics, stochastic processes, seismology and/or physics preferred. MS in a physical seismology and/or physics preferred. MS in physical science preferred, Ph.D favored. Refer to Box 54PAN.

Send CV/ resume to:

Personnel Office,
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Must have good writing ability and customer contact experience. Will be a key contributor to the synthesis of advanced avionics systems. MS level or above engineering degree preferred, with a minimum of ten years experience in a systems engineering assignment dealing with inertial navigation, and/or guidance systems for aerospace applications. Experience in developing or testing of operational inertial navigation systems is highly desirable.

For immediate consideration send resume, including salary history, to:
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POSTDOCTORAL FELLOWSHIP

The Laboratory of Neurosciences of the National Institute on Aging, National Institutes of Health, Public Health Service, seeks a qualified candidate for a postdoctoral fellowship (Staff Fellow/Senior Staff Fellow - Tenure Track) in neurosciences and biomedical computing. The successful candidate will be part of a multidisciplinary team conducting studies of normal and disordered human functional neuroanatomy using positron emission tomography (PET) and magnetic resonance imaging (MRI). This position will be dedicated to the development of new methods for image processing neuroanatomical localization, statistical analysis, and neural systems modeling. Background in neuroscience, image processing, mathematical modeling, and statistics desired. The position is located at the NIH campus in Bethesda, Maryland. Applicants should send current curriculum vitae and a letter discussing research interests and experience to:

James V. Haxby, Ph.D., Laboratory of Neurosciences, NIA, National Institutes of Health, Building 10, Room 6C414, 9000 Rockville Pike, Bethesda, MD 20892.

Position information and qualification requirements may be obtained by contacting: Dr. James V. Haxby at (301) 496-5882 or FAX: (301) 402-0595.

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GROUP SUPERVISOR

The Jet Propulsion Laboratory in Pasadena, a federally funded R&D center operated by the California Institute of Technology for NASA, has an exciting opportunity in the Radiation Effects and Testing Group supporting JPL flight projects by assuring the reliability and quality assurance of microelectronic parts.

You will participate in either total dose or single event effects testing and research on semiconductor devices and circuits; develop and execute radiation tests and electrical characterization of microelectronic parts; interact with flight project parts specialists concerning radiation issues; and report research and test findings to NASA and the radiation community.

Requires BS, MS or PhD degrees in fields related to radiation effects in microelectronics, and experience in developing test software and hardware for electronic parts. Experience using sophisticated electronic test equipment and radiation sources, such as Co-60, heavy ion accelerators, Cf-252 SEU simulators and pulsed laser systems also desirable. Strong written and oral communication skills are also necessary.

Please send resume to Department T-19, Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive 249/104, Pasadena, CA 91109. Equal Opportunity Employer.

JPL

Jet Propulsion Laboratory
California Institute of Technology

ENGINEERS, PHYSICISTS, ASTRONOMERS

The California Institute of Technology operates a submillimeter observatory on Mauna Kea, Hawaii, known as the Caltech Submillimeter Observatory (CSO). The Observatory consists of a 10.4 m Leighton telescope on the mountain, a sea-level base in Hilo, Hawaii, and a research laboratory in the Downs Laboratory of Physics in Pasadena, California. (The telescope operates at wavelengths from 1 mm to 300 μ m, using superconducting tunnel junction (SIS) receivers for spectroscopy and bolometers for continuum studies, all operating at liquid helium temperatures.

Positions are available for astronomers, physicists or engineers to work as support staff at the Observatory in Hawaii. Opportunities for observing and for contributing to instrument development would be available to suitably qualified scientists.

A position may be available in Pasadena, for a suitably qualified applicant, to work on development of bolometer instrumentation and to contribute to the research program.

Applicants should have a research degree in either Astronomy, Physics or Electrical Engineering, or equivalent experience in radio, millimeter, submillimeter or infrared techniques. Extensive experience in electronic engineering would also be considered appropriate. The individuals selected must possess a physical examination showing aptitude to carry out assignments at an altitude of 14,000.

Resumes should be sent to **Caltech Employment Department, Position #140-2, 1201 E. California Blvd., Mail Code 101-6, Pasadena, CA 91125.**

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Caltech



Princeton University
School of Engineering and Applied Science

Faculty Position in Micromachining

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A doctorate is required, and some post-doctoral experience in research or teaching is desirable. The search is directed at the assistant or associate professor rank, although more senior appointments can be considered for exceptional candidates.

Applications including a comprehensive resume and a list of references should be submitted to:

Prof. Garry L. Brown
Chairman, Mech. & Aero. Engrg.
D-216 Engineering Quadrangle
Princeton University
P.O. Box CN5263
Princeton, NJ 08544-5263

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Previous license or certification as SRO highly desirable. BWR experience preferred. Salary: low to mid \$50's.

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Positions in Mechanical Design, Electrical Design, Civil Design, C&I Design. Salary: high \$40's to low \$50's.

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Min. of 5 yrs. experience in operating nuclear plant on-line radiation monitoring system, which is microprocessor-controlled. Familiarity with Eberline process radiation and area radiation monitors is essential. Salary: high \$40's to low \$50's.

SUPERVISING ENGINEER/SPECIALIST — CHEMISTRY

Min. of 6-8 yrs. experience in BWR Chemistry and project management experience. Salary: high \$40's to low \$50's.

SUPERVISING ENGINEER — ENVIRONMENTAL QUALIFICATION

Min. of 8 yrs. experience in environmental qualification, with strong nuclear background, design and systems knowledge of BWR. Salary: mid \$40's to low \$50's.

ELECTRICAL DESIGN — STAFF ENGINEER/SPECIALIST

Experience in relay and breaker coordination preferred. Salary: low to mid \$40's.

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Openings in control & instrumentation; health physics; electrical; mechanical; and chemistry. Commercial, nuclear, military or industrial experience is preferred. Salary: mid \$30's.

For consideration, send your resume, indicating the position to which you are applying, to: **Employee Relations Department SM, V-405, ILLINOIS POWER, Clinton Power Station, P.O. Box 678, Clinton, IL 61727; or Fax resume to: (217)424-6462.** An equal opportunity employer m/f/h/v.

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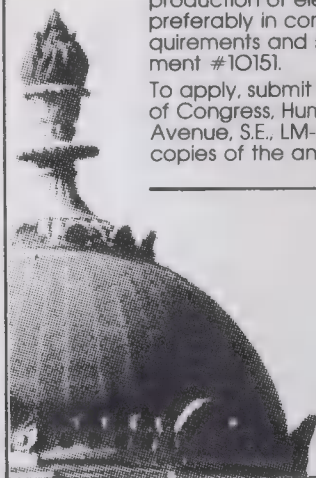
Supervisory Electronics Engineer

Head, Engineering Section GS-855-14

The Library of Congress, National Library Service for the Blind and Physically Handicapped, is seeking qualified applicants for the position of Head of the Engineering Section of the Materials Development Division. The section is engaged in the design and production of a wide range of electronic and electro-mechanical equipment used in a national program for providing alternative reading materials to over 500,000 U.S. citizens who cannot read print materials due to a visual or physical handicap.

Candidates must have at least a Bachelor's degree in Electronics Engineering, plus a minimum of three years of professional experience that provided practical knowledge of the specification, design, and production of electronic systems, circuits, hardware, and software, preferably in consumer audio or a related field. Qualification requirements and substitutions are stated in full in Vacancy Announcement #10151.

To apply, submit Standard Form 171, no later than May 31, to the Library of Congress, Human Resources Operations Office, 101 Independence Avenue, S.E., LM-107, Washington, D.C. 20540. For information and copies of the announcement call (202) 707-5601.



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Christenson Engineering Corporation, located in the beautiful Pacific Northwest, provides engineering and design services to the petroleum industry and pulp mills in the Northwest and Alaska. Our growth reflects our commitment to produce quality work.

We are currently seeking experienced and degreed professionals in:

Electrical Engineering

Minimum requirements include 5 years of strong technical experience in short circuit calculations, load flow studies and protective device coordination. Must be familiar with the requirements of electrical systems for: switchgear, lighting, grounding, National Electrical Code, and project control. Experience in a consulting engineering environment with at least 3 years recent experience in the oil refinery industry is highly desirable. P.E. is desirable. BSEE required.

Your commitment to excellence is rewarded with a competitive compensation and relocation assistance package. For immediate consideration please send your resume to: **Human Resources, Christenson Engineering Corporation, P.O. Box 5098, Bellingham, WA 98227-5098 or FAX: (206) 734-7022.** An Equal Opportunity Employer.



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Responsible for top level conceptual engineering of tactical data networks and development of strategic technologies. Interpret DoD operational requirements and objectives to develop system functional and performance requirements. Should have experience in network design/layout, network performance analysis, network protocols, X.25, 802.3, domain name servers, electronic mail systems, and UNIX operating systems.

In addition to the requirements listed in the above positions, candidates must possess a BS/MS in Systems Engineering, Electrical Engineering, Computer Science or a related discipline. At least 8 years of experience in systems engineering, development and integration is also required. Relevant military experience is highly desirable.

Qualified candidates for these positions may send resumes to:
Arnold Amirault, GTE Government Systems - Command, Control and Communications Systems, Human Resources/Dept. 238,
400 John Quincy Adams Road, Taunton, MA 02780.

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Venus, thy names are women

It's a cartographer's dream, or nightmare. The Magellan spacecraft's imaging radar is mapping the surface of Venus and someone has to name the 4000 or more features that are likely to be identified. So the scientists of the Magellan Project at the Jet Propulsion Laboratory, along with the Flagstaff, Ariz., office of the U.S. Geological Survey, have appealed to the world for suggestions.

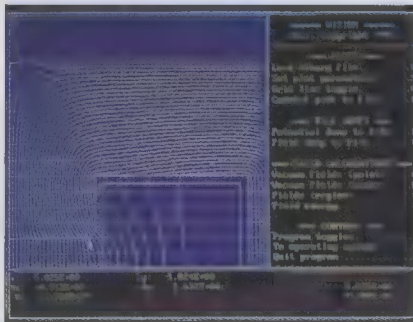
Since previous agreements have made the International Astronomical Union the supreme authority of solar system nomenclature, the suggestions must follow the union's rules: all newly discovered features must be named after women; some features can be named after goddesses of ancient religions and cultures; and craters are to be named for real, notable women, deceased for at least three years. Prohibited are 19th and 20th century political and military figures and women prominent in any of the six main, modern religions.

The team needs the dates of the woman's birth and death, a one- or two-sentence rationale of her historical importance, and, if available, a reference book citation. *Contact: Venus Names, Magellan Project Office, Mail Stop 230-201, Jet Propulsion Laboratory, 4800 Oak Grove Dr., Pasadena, Calif. 91109.*

SOFTWARE

Meshing triangles with Poisson

Calculating the electric and magnetic fields around complex two-dimensional geometries can be very time-consuming. One product that can help lessen the time in getting these figures is Poisson. With this soft-



ware package, the geometry of electrodes, coils, dielectrics, poles, and other objects can be entered by hand or, with an optional package, transferred from an Autocad drawing. The program then creates a mesh of triangles to approximate the geometry and cal-

culates the electrostatic potential values within the mesh. Output includes plots of equipotentials or field lines, electric or magnetic field values at specific points, and the physical force on any object.

Poisson runs on an IBM PC or compatible and costs US \$585. *Contact: Acceleration Consultants, 53 Rock Point Place, N.E., Albuquerque, N.M. 87122; 505-296-6689; or circle 100.*

this hardware or software?

Ever try reading a schematic with thousands of gates on it? Probably not; circuits that size have to be represented differently. One such representation is VHSIC (Very High-Speed Integrated Circuit) Hardware Design Language (VHDL). This development system allows a digital designer to write, compile, and debug high-level code and produce a working design.

VHDL's Pascal/Ada-like syntax is defined by IEEE Standard 1076. It can be used to design or simulate any digital application, but most usage is in programmable logic arrays, gate arrays, and application-specific ICs that contain 500 to a few thousand gates.

V-System/Windows is available for \$1495. It requires an IBM PC or compatible, 4M bytes of memory, a hard disk, and Microsoft Windows 3.0. A DOS version is also available. *Contact: Model Technology Inc., 15455 N.W. Greenbrier Parkway, Suite 210, Beaverton, Ore. 97006; 503-690-6838; or circle 101.*

CATALOG

Over 600 IEEE Standards

Hot off the presses is the IEEE Spring/Summer 1991 Standards Catalog, a listing of over 600 standards encompassing every aspect of electrical engineering. Standards range from the esoteric (melting glass with electric heaters) to the commonplace (in such areas as aerospace, antennas, circuits, communications, computer systems, instrumentation and measurement, magnetism, power electronics, and software).

The widely used standards serve several purposes. They allow products made by a number of different manufacturers to successfully interface with each other. Other standards recommend safe or reliable practices.

Free copies are available. *Contact: IEEE Standards Office, 445 Hoes Lane, Box 1331, Piscataway, N.J. 08855-1331; 908-562-3800; or circle 102.*

COORDINATOR: Dennis DiMaria
CONSULTANT: Paul A.T. Wolfgang, Boeing Helicopters



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Corporate Culture

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RECENT ADVANCES IN ROBUST CONTROL

Edited by Peter Dorato, University of New Mexico, and Rama K. Yedavalli, Ohio State University

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This new volume provides an in-depth review of the newest developments in robust control of uncertain systems as they were reported at major control conferences held in 1988 and 1989. Valuable introductory and explanatory material precedes each subject discussed, defining new research and applications.

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The book is of special interest to engineers working in the following areas: process control, flight control, robotics, automobile control, space control applications, power systems, marine control sys-

tems, manufacturing systems, and feedback amplifiers.

1990 ISBN 0-87942-266-1, Order #PC0258-4, Hardcover, 512 pp.

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How to keep up? ESAP!

Keeping up and finding ways to keep up is an almost insurmountable challenge for the engineer in industry and academia in today's environment. The IEEE has developed the Engineering Skills Assessment Program (ESAP), a system with speedy, "short circuit" paths for circulating skill and knowledge requirements among industry, academia, and the engineer. The system provides for self-assessment and guidance in and out of the field, and is a viable means for nurturing lifelong learning.

Twenty-one of an anticipated 100 fields have been prioritized for development using criteria based on membership interest as determined by the Technical Interest Profile (TIP). They are:

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IEEE Members' Professional Needs

This IEEE Position Paper was developed by the United States Activities Board and approved by the IEEE Board of Directors. It discusses at some length the following six professional needs:

1. A lifetime engineering career with adequate compensation and retirement provisions.
2. A positive work environment that provides technical challenges and incentives for creativity.
3. Public and peer recognition for technical and professional contributions to the profession.
4. Continued high standards for entering, practicing, and continuing the education for the profession of engineering.
5. Broad recognition and respect for a code of ethics.
6. Increased recognition of the role of engineering in helping to deal with a wide array of societal problems.

This Position Paper serves to guide IEEE programs

that implement the Institute's professional purpose.

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1990 IEEE MEMBER OPINION SURVEY

This publication is the result of the first worldwide IEEE member opinion survey. Topics such as employment, education levels, use of computers in the workplace, and important issues for electrical engineers in the 1990s are included in the core section. U.S. and non-U.S. members were also sent questions about their particular needs. Responses from U.S. members include a ranking of the importance of various professional issues to the individual member and to the profession as well as comments on the status of educational services in the United States. Non-U.S. members were asked about such matters as membership in other technical societies and attendance at IEEE conferences worldwide.

List Price: \$19.95 IEEE Member Price: \$7.50

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IEEE CODE OF ETHICS

Engineers affect the quality of life for all people in our complex technological society. In the pursuit of their profession, therefore, it is vital that engineers conduct their work in an ethical manner that will merit them the confidence of colleagues, employers, clients, and the public. The IEEE Code of Ethics represents this standard of professional conduct for

engineers.

IEEE-USA has printed the IEEE Code of Ethics as revised by the Board of Directors in November 1987. The Code is being made available on parchment suitable for framing (12 inches by 16 inches) from the IEEE Service Center (800-678-IEEE) at a cost of \$5. Members are encouraged to use these parchment Code copies as gifts or service awards in local activities. A printed 8 1/2-by-11-inch version of the Code is also available free of charge.

For a complimentary printed copy of the IEEE Code of Ethics, **CIRCLE #88 on the Reader Service Card.**

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Editors: C. Toumazou, F. J. Lidgley, and D. G. Haigh

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668 pp., casebound, 1990 US \$85.00

To order, contact the PPL Department/IEEE Service Center, 445 Hoes Lane, Box 1331, Piscataway, N.J. 08855-1331; 201-562-5557; fax, 201-981-0027.

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The following listings of interest to IEEE members have been placed by educational, government, and industrial organizations as well as by individuals seeking positions. To respond, apply in writing to the address given or to the box number listed in care of *Spectrum* Magazine, Classified Employment Opportunities Department, 345 E. 47th St., New York, N.Y. 10017.

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Positions wanted: \$34.00 per line, a 50% discount for IEEE members who supply their membership numbers with advertising copy

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IEEE encourages employers to offer salaries that are competitive, but occasionally a salary may be offered that is significantly below currently acceptable levels. In such cases the reader may wish to inquire of the employer whether extenuating circumstances apply.

Academic Positions Open

The University of Texas at Austin, Department of Electrical and Computer Engineering, is accepting applications for a tenured faculty position with the rank of professor in electromechanics/electromagnetics. Duties will include leadership of an internationally competitive research program, program development in classical electromagnetics, and the teaching of undergraduate and graduate level courses. Interested applicants are invited to send resumes which detail their past professional accomplishments, and which include the names and addresses of at least three references, to Dr. Mario J. Gonzalez, Chairman, Department of Electrical and Computer Engineering, The University of Texas at Austin, Austin, TX 78712-1084. The University of Texas at Austin is an Equal Opportunity/Affirmative Action Employer.

Iowa State University. The Department of Electrical Engineering and Computer Engineering invites applications for anticipated tenure-track faculty positions at all ranks beginning Fall 1991 semester. The primary need is for specialization in the areas of communications/signal processing, computer networking/data communications, control, microelectronics, and power. Responsibilities include teaching, research and outreach. Salary and rank are commensurate with qualifications and experience. Applicants must possess a doctorate degree with demonstrated potential for research. Applications should include a resume with a statement of teaching, research, and outreach interests, as well as a list of at least three (3) references. Applications should be sent to: Dr. John Wm. Lamont, Chairman of Faculty Search Committee, Department of Electrical Engineering and Computer Engineering, Iowa State University, Ames, Iowa 50011. Iowa State University is an Equal Opportunity/Affirmative Action Employer.

Faculty Positions—The Citadel, the Military College of South Carolina, in Charleston, solicits applications for a faculty position in Electrical Engineering, with initial appointment for up to two years. Conversion to tenure track, subsequent to appointment, may become possible. The position is at the Assistant or Associate Professor level with a competitive salary commensurate with qualifications. The Ph.D. degree is preferred, and the ability and desire to teach in an undergraduate Electrical Engineering program (including evening classes) are essential. U.S. citizenship or permanent resident status is required. Opportunities for locally supported research are limited, but expanding. Specializations preferred are in the areas of power and communications. Deadline: June 20, 1991, or until positions are filled, with ongoing screening of applications. Starting date: August 20, 1991. Send resume and list of three references to Dr. Harold W. Askins, Jr., Professor and Head, Department of Electrical Engineering, The Citadel, Charleston, SC 29409. Telephone: 803-792-5057.

University of Wisconsin-Madison, Philip Dunham Reed Chair in Electrical & Computer Engineering. The University of Wisconsin-Madison is resuming its search for a highly qualified and internationally recognized scien-

tist or engineer to fill the Endowed Philip Dunham Reed Chair in Electrical and Computer Engineering. Applications or nominations should be sent to: Professor Bahaa E.A. Saleh, Chairman, Department of Electrical and Computer Engineering, University of Wisconsin-Madison, 1415 Johnson Drive, Madison, WI 53706-1691. Previous applications and nominations will be automatically reconsidered. The University of Wisconsin-Madison is an equal opportunity/affirmative action employer.

Faculty Positions in Electrical Engineering. The Department of Electrical Engineering and Computer Science at the University of Wisconsin-Milwaukee invites applications for faculty positions at all professorial ranks. Preferred areas of interest include, but are not limited to, electromagnetics, solid state electronics and VLSI. Qualifications include an earned Ph.D., a commitment to research and teaching and the ability to carry out a funded research program. Applicants for senior positions are expected to have a distinguished record of accomplishment. Applicants should send a resume and the names of at least three references to: J.D. McPherson, Chair for Electrical Engineering, Department of Electrical Engineering and Computer Science, University of Wisconsin-Milwaukee, P.O. Box 784, Milwaukee, WI 53201. UWM is an Equal Opportunity (M/F)/Affirmative Action Institution.

Postdoctoral Position in Control Engineering, Ecole Polytechnique Federale de Lausanne (EPFL), Switzerland. The Institut d'Automatique is engaged in school-wide teaching and research which results in a highly multidisciplinary approach to control. A postdoctoral fellow with a strong theoretical background and proven talent for communication is sought to lead selected areas of research that include adaptive and robust control, state estimation and nonlinear filtering, and control of DEDS. The initial appointment is for one year, but the position can be renewed or even turned into a permanent senior position. The position has a highly competitive salary. Please send your application to Prof. D. Bonvin, Institut d'Automatique, EPFL, 1015 Lausanne, Switzerland. Phone number 41-21-693-3843, FAX number 41-21-693-525, e-mail address bonvin@elia.epfl.ch.

The University of Toledo. The Computer Science and Engineering Department invites applications for tenure track faculty positions at the Assistant Professor level in Computer Science or Computer Engineering beginning in September 1991. We are especially interested in applicants with an interest in microcomputer systems design or operating systems. CSE faculty are currently engaged in a number of research projects including industrial vision, systems, programming environments, networking, parallel processing, and performance evaluation. Faculty participate in the College's interdisciplinary Engineering Science graduate program. External research support is possible with the Edison Industrial Systems Center, funded by the State of Ohio and a consortium of industrial organizations. Facilities available, in addition to University main frames and time on the Ohio Supercomputer, include networked Sun workstations, a VAX 11/780, HP and Intel microcomputer development facilities, a 16 processor CSA Superset, and IBM and Intel PCs. Departmental machines are interconnected via Ethernet which also connects each faculty office to

departmental and University facilities. Applicants must have completed the Ph.D. in Computer Science or Computer Engineering before beginning employment. Salary will depend upon qualifications and experience. Please send resume containing names and addresses of three references to: Dr. Hilda Standley, Chair, Faculty Search Committee, Computer Science and Engineering, South Engineering Building, University of Toledo, Toledo, OH 43606-3390. (e-mail address: csechair@uoftcse.cse.utoledo.edu) The University of Toledo is an equal opportunity/affirmative action employer.

Howard University Department of Electrical Engineering Power Systems and Controls Engineering. Research Associate. The Power Systems and Controls Engineering Research Group, Electrical Engineering, Howard University, invites applications for a Research Associate position. Applicants must hold a Ph.D. in Electrical Engineering (earned within the last two years) with a specialization in power systems. Exceptionally qualified individuals having an established research record in the fields of: power systems, relay protection, advanced topics in optimization and writing production type programs, are of particular interest. Qualified applicants should send a resume, including a statement of research interests and a list of three (3) references to: Dr. James A. Momoh, Director, Power Systems and Controls Engineering, Department of Electrical Engineering, Howard University, Washington, DC 20059. Howard University is an Equal Opportunity/Affirmative Action Employer.

The Department of Electrical Engineering at Tulane University has an opening starting in the Fall 1991 semester, for a full-time, tenure track faculty position. Duties include teaching graduate and undergraduate courses, research, and advising students. Rank and salary are commensurate with qualifications. Requirements: Doctorate in Electrical Engineering with a specialty in power or must have completed all requirements for this degree except dissertation within the year prior to selection, with expected completion of dissertation prior to inception of employment. Complete vitae with a minimum of three references should be sent to Dr. S.T. Hsieh, Department of Electrical Engineering, Tulane University, New Orleans, LA 70118-5674, (504) 865-5785. All candidates should indicate citizenship and, in the case of non-US citizens, describe their visa status. Tulane University is an equal opportunity/affirmative action employer.

The Department of Electrical Engineering at the University of Kentucky invites applications for an anticipated tenure track faculty position in the area of power electronics, for appointment on July 1, 1991. The applicant should hold an earned Doctorate in Electrical Engineering and have a sincere interest in research and teaching at both the undergraduate and graduate levels. Although applicants with interest in any aspect of power electronics will be considered, preference will be given to individuals with specialty in either high-speed switching applications in adjustable speed drives or switched-mode power supplies. The ideal candidate should also have interest in microprocessor and DSP controls applied to power electronics problems. This newly established faculty position offers a unique opportunity for a qualified and energetic person to build his/her own re-

CLASSIFIED EMPLOYMENT OPPORTUNITIES

search program and course offerings to complement and extend an already established activity. Qualification to seek extramural funding from both industry and government agencies is expected. Interested individuals are invited to send a letter of application, a resume, and a list of three references to Dr. S.A. Nasar, Chairman, Department of Electrical Engineering, University of Kentucky, 453 Anderson Hall, Lexington, KY 40506-0046. Women and minorities are encouraged to apply. The University of Kentucky is an equal opportunity and affirmative action employer.

Knight Chair in Biomedical Engineering. The Biomedical Engineering Department, University of Miami, invites nominations and applications for its new Knight Chair in Biomedical Engineering. It is expected that candidates will have an outstanding reputation in research, an established record in external funding, and a commitment to education. A person is sought who would establish a strong research link with some branch of the University of Miami School of Medicine. The Department offers M.S. and Ph.D. programs and undergraduate options in other branches of engineering. The University is located in beautiful Coral Gables, within the Miami metropolitan area. Nominations and applications with the names of three references should be sent to Dr. Eugene Eckstein, Biomedical Engineering Dept., PO Box 248294, University of Miami, Coral Gables, FL 33124-0621. The University of Miami is an Equal Opportunity/Affirmative Action employer.

Parks College of Saint Louis University Tenure-Track Appointment-Avionics. The Department of Aerospace Technology at Parks College of Saint Louis University is seeking qualified applicants for tenure-track appointment in Avionics at the Assistant or Associate Professor level. Candidates must possess at least a M.S. degree in electrical or electronic engineering and have current experience in aviation electronics. Candidates must be committed to quality teaching and research. Interested persons should send curriculum vitae and bibliography to: Dr. Richard Andres, Department of Aerospace Technology, Parks College of Saint Louis University, Cahokia, IL 62206 EOE M/F/H/V.

Tenure Track Position—Assistant or Associate Professor—Electronics & Electromechanical Technology; Upper Division Program—requires Ph.D. or MSEE plus P.E. License, plus industry experience. Resumes to: Dr. Samuel Derman, Chairman/Department of Engineering Technology, City College of New York, 140th St at Convent Ave. NYC, 10031. An AA/EEO Employer M/F.

Department Head—The Department of Engineering Technology at Western Kentucky University is seeking a Department Head to assume responsibilities as early as September, 1991, but no later than July 1, 1992. Programs offered are TAC/ABET accredited BS curricula in Civil, Electrical and Mechanical Engineering Technology and a new BS program in Electro-Mechanical Engineering Technology. Minimum of a Master's Degree in Engineering with P.E. or Ph.D. (preferred) and evidence of administrative leadership/effective teaching/industrial experience. Send letter of application, vita and names of three references with phone numbers, and transcripts, to: Office of Academic Affairs, ET Head Search, Western Kentucky University, 1526 Russellville Road, Bowling Green, KY 42101-3576. Application deadline August 1, 1991. Women and minorities are encouraged to apply. Affirmative Action/Equal Opportunity Employer.

Endowed Chair in Electrical Engineering at Georgia Tech. The Georgia Institute of Technology is seeking candidates for the Joseph M. Pettit Chair in the School of Electrical Engineering. Applications and nominations for this endowed chair are now being accepted. It is expected that the chair holder will play a principal role in the definition and development of future programs in the area of computer engineering and/or closely related areas. Candidates must have a record of distinguished performance and well established potential for providing leadership in research and instructional program development. Salary and program development funds available for support of this distinguished position are fully competitive. Re-

sumes and nominations should be submitted by September 2, 1991 and addressed to: Director, School of Electrical Engineering, Georgia Institute of Technology, Atlanta, GA 30332-0250. Georgia Tech is an equal opportunity, affirmative action employer.

Washington University seeks qualified candidates for the position of Professor and Chair of the Department of Systems Science and Mathematics, with a desired starting date of July 1, 1992. We are interested in outstanding candidates with a strong research record, with a dedication to excellence in undergraduate and graduate education and with a demonstrated potential for administration and leadership. Washington University has a long standing commitment to the principle that all candidates should be afforded equal opportunity regardless of age, race, sex or physical disability. Candidates must send a curriculum vitae and a list of references to: Professor C.I. Byrnes, Search Committee for the Systems Science and Mathematics Chair, Campus Box 1040, Washington University, One Brookings Drive, St. Louis, MO 63130.

Engineering Technology Faculty Position beginning fall 1991 to teach electromechanical systems, control systems, logic controllers, automation, and CIM. Bachelor's Degree in Engineering or Engineering Technology required, Master's preferred. Salary based on education and experience. Reply to Donal Staake, Chairperson, Jackson Community College, 2111 Emmons Road, Jackson, MI 49201.

Positions Available. Center for Electro-Optics University of Nebraska-Lincoln. Seek outstanding individuals for research appointments totally within the cross-disciplinary Center or jointly with an academic department. Applicants should have a research linkage to at least one of the following areas: applied optical measurements, electromagnetics and scattering calculations, computer graphics, remote sensing, linear and nonlinear interaction of lasers with matter, ultrafast optical phenomena, nanostructures, and laser welding processes. Job responsibilities include providing scientific and technical leadership, supervising graduate students, teaching graduate or undergraduate courses and mentoring junior faculty. Qualifications include Ph.D. in appropriate discipline; proven capability to develop and manage extramurally funded research projects; achievements and publications to warrant the level of appointment ranging from post doctorate to distinguished faculty. Submit detailed resume and the names of at least four references to: Dr. Dennis R. Alexander, University of Nebraska, Lincoln, NE 68588-0656. (The immigration status of a non-citizen must be stated in the resume.) Applications received by June 1 will receive first round consideration for September 1 starting dates; however, applications will be accepted until suitable candidates are found. Affirmative Action/Equal Opportunity Employer.

University of Guam, Division of Mathematical Sciences. The University of Guam solicits applications for the following tenure track position: Instructor to Associate Professor of Computer Science. Candidates must have at least a Master's Degree in Computer Science with teaching experience at the tertiary level. Preference will be given to candidates with an earned Ph.D. in Computer Science. The successful candidate must have a strong commitment to quality teaching of both remedial students in mathematics and college level student in mathematics and computer science, and a demonstrated interest in the development of a new degree program in computer science. Applicant must be a U.S. citizen or permanent resident prior to employment. Rank and salary commensurate with qualifications and experience. Salary: Instructor—\$30,541-\$44,481 per academic year. Assistant Professor—\$33,634-\$49,770 per academic year. Associate Professor—\$38,529-\$58,144 per academic year. Requests for official application forms and other information may be directed to the Personnel Services Division, UOG Station, Mangilao, Guam 96923. Send completed applications forms, updated resume or curriculum vitae, official graduate transcripts (sent directly from awarding institution/s), copies of undergraduate transcripts, three letters of reference for

placement file to: Dr. Henry J. Taijeron, Chair, Computer Science Search Committee, c/o Personnel Services Division, UOG Station, Mangilao, Guam 96923. The selection process will begin April 15, 1991, and continue until the position is filled. EEO/AAE.

University of Texas at Arlington. The Department of Electrical Engineering invites applications for tenure-track faculty positions in the following areas: remote sensing and wave scattering, high speed electronics, and applied physical electronics. A Ph.D. and a background in electrical engineering is required. The department presently has 30 faculty and graduates 150 BS, 110 MS and 12 PhDs annually. It has an annual research volume of \$3M. The university is located in the heart of the Dallas/Ft. Worth metroplex, 30 miles north of the site of the superconducting super collider. Please send resume and names of reference to Professor Robert Mitchell, Department of Electrical Engineering, University of Texas at Arlington, Box 19016, Arlington, Texas 76019-0016. The University of Texas at Arlington is an Equal Opportunity/Affirmative Action Employer.

Iowa State University Power Engineering Graduate Studies. The power systems area of the Department of Electrical Engineering and Computer Engineering invites graduate student applications for new students beginning for the Fall 1991 semester. Areas of research include power system dynamics, voltage stability, and power system operation and scheduling. Fellowships and research assistantships are available for qualified U.S. citizens and permanent residents who meet the department's admission requirements. Applicants must possess a bachelors or masters degree. Interested persons should send a resume with a statement of educational and career objectives as well as a list of at least three (3) references. Applications should be sent to: Department of Electrical Engineering and Computer Engineering, Iowa State University, Ames, IA 50011, Attention: Graduate Admissions (for admissions (515) 294-2667) or the Power System Area (for financial aid (515) 294-8057). For primary consideration for the fall 1991 semester, applications must be received by June 1, 1991.

Senior Lecturer/Lecturer in Electronic Materials and Devices, Interdisciplinary Engineering Program, Faculty of Science, The Australian National University. Applications are invited for a tenurable position at the senior lecturer/lecturer level. A PhD in electrical engineering, specializing in electronic materials and devices is essential. The successful candidate is expected to contribute to both the undergraduate teaching and research activities. Strong links exist between the IEP and the Department of Electronic Materials Engineering in the Research School of Physical Sciences and Engineering, Institute of Advanced Studies, ANU. Research facilities in electronic materials engineering include full VLSI design software suite and extensive material laboratory facilities (including plasma etching and lithography, SEM). The IEP is a young, dynamic program in the Australian National University with excellent funding from both university and external sources. Further information can be obtained from Professor D. Williamson, e-mail darrell@faceng.anu.edu.au, or phone int+61+6+249 3378, (06) 249 3378. Closing date: 15 June 1991. Ref. IEP 27.3.2. Salary: Senior Lecturer: A\$43,984-A\$51,015 p.a.; Lecturer: A\$33,163-A\$43,096 p.a. Applications should be submitted in duplicate to the Registrar, The Australian National University, GPO Box 4, Canberra ACT 2601, Australia quoting reference number and including curriculum vitae, list of publications and names of at least three referees. The University reserves the right not to make an appointment or to appoint by invitation at any time. Further information is available from the Registrar. The University is an Equal Opportunity Employer.

Government/Industry Positions Open

Electrical Engineer wanted. Duties: Conduction research & development activities concerned with design, manufacture & testing of proposed automotive test work station, including designing & developing the required computer hardware; designing & developing electronic cir-

cuits & other equipment as well as computer software to interface the computer with sensors contained in automobiles for data acquisition & high frequency analysis purposes; testing automobiles for radiation, emission, stability, & engine frequency. These duties will be performed using VAX computers, UNIX operating system & C & HPBasic languages. Requirements: Master's in Electrical Engineering, 1 yr exp as an Electrical Engineer or Graduate Assistant in Electrical Engineering. The required experience must have included computerized data acquisition from an automotive electrical system. 1 univ. course or related exp. must also include each of the following: high frequency analysis; programming using VAX computers; UNIX operating system: C & HPBasic languages. Designing & developing vehicle test software. Pay is \$39,600 per yr. 40hr/wk. Resumes to 7310 Woodward Ave., Rm 415, Detroit, MI 48202. Ref. #5891. Employer Paid Ad.

Help Wanted: Product Specialist, International Sales (2 positions). Send resume on or before May 31, 1991 to: Employment Security Department, ES Division, Olympia, Washington 98504, Attn: Job order No. 251144. Job Description: Responsible for providing technical training for country sales organization, and providing technical support to sales organizations in assigned product areas. Will provide and/or coordinate customer product training for international customers. Will assist in implementation and maintenance of sales programs for assigned products. Responsible for assisting in the development of sales plans, quotations and customer proposals. Will provide product information on a regular basis to country product specialists. Will conduct product seminars in key international markets. Responsible for developing/maintaining a 12-month sales pipeline by country for assigned product range. Requirements: B.S. or equivalent in electrical engineering or electronics engineering technology, 6 months of related occupation as applications engineer/sale engineer in precision electronics; must be able to read, write and speak the English language, plus the Mandarin and Cantonese dialects of the Chinese language. Must be willing to travel foreign and domestic 35-40% of working time. Salary: \$781.20 per week, with no overtime. Position Offers: Prevailing working conditions, 40 hours per week, 8:00 a.m. to 5:00 p.m., Monday through Friday. Headquarters in Everett, WA. On the job training not offered, equal opportunity employer. Must have proof of legal authority to work in the United States.

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Engineer Equipment. Resp. for process engrg & maintenance to optimize semiconductor manufacturing equipment, with primary emphasis on Anelva 1015 sputtering system; duties incl. hardware redesign, software reprogramming & enhancements, service enhancements, service evaluation & maintenance of subassemblies. Reqs. BS in Electrical or Electronics Engrg plus 3 yrs. exp. as Equipment

Engineer. Exp. should also incl. 3 yrs. exp. with Anelva modification, software upgrades, modification of schematics for electrical redesign. Also reqs. understanding of semiconductor manuf. process & of metallurgy as relates to contamination control, equipment modification & ionic lifetime measurement. Salary: \$43,140/yr. Job & interview site: San Antonio, Texas. Apply at the Texas Employment Commission, San Antonio, Texas, or send resume to the Texas Employment Commission, TEC Building, Austin, Texas 78778, J.O. #6344416. Must have legal right to work. Ad paid by an Equal Employment Opportunity Employer.

Electrical Engineer, responsible for signal processing algorithms and architectural design for digital communication systems. Design, analyze, and perform computer simulation for DSP chip architecture, including AGC algorithm, symbol timing recovery algorithm, echo canceller, adaptive equalizer, digital phase-locked loops and digital filters. Perform design, analysis, and computer simulation, using UNIX, C, and X-Windows. Reqs. Ph.D. in electrical engineering, and one year in job or one year of experience including the design, analysis and implementation of image processing and adaptive signal processing algorithms, and the implementation of high speed modem and DSP system, using UNIX and C, programmable Digital Signal Processors and custom ICS. Job/interview site: Berkeley, CA. \$55,000/yr. Send resume to Job #SS 19162, P.O. Box 9560, Sacramento, CA 95823-0560, no later than May 31, 1991. EOE.

Customer Service Manager (Telecommunications). Resp. for direction and management of Customer Svc. Dept. & staff providing support for telecommunications software systems; develop dept. policies & procedures; train & direct staff in fault analysis & resolution & pro-active maintenance; monitor faults & problem resolution efforts for all products; and related responsibilities. Reqs. Bachelor's degree (or educ. & exp. equiv. to degree) in E.E., E.E. Tech., or Comp. Sci., plus reqs. 5 yrs. exp. in technical support/customer svc. (telecommunications). Or if H.S. diploma only, reqs 10 yrs exp. in Technical Support/Customer Svcs. (telecommunications). In either case, exp. must incl. at least 3 years exp. in technical/group mgmt. & UNIX-based programming; reqs. knowl. of relational databases, SQL, knowl. of systems design & analysis methodology. All exp. may be gained concurrently. Salary: \$49,500/yr. Send resumes to B. Herman, NYS Dept. of Labor, 140 W. Main St., Rochester, NY 14614. Refer to NY0500052.

Research & Development Director for Electric Vehicles—Englewood—Direct the research & dev. of advanced electric vehicles using brushless dc motor concepts. Explore market for products & seek out potential manufacturing sources/partners in Asia & the Pacific basin. Serve as an internal consultant on dev. & application of state-of-the-art motion control theory to variable speed electric drives for vehicles & robotics & brushless dc motor concepts. \$50,000/yr. 40hrs/wk. Ph.D. in Electrical Engin'g. 5 yrs exp. Fluency in Japanese. Must have knowl. of Brushless DC Motor Concepts in electrical vehicle in electrical controls. Resume only to: CO Dept. of Labor & Employment, 600 Grant St., Suite 900, Denver CO 80203 & refer to JO# CO 3195411.

Boiler Instrumentation Engineer for NE Ohio district utility company. Design, install, calibrate and repair digital electronic process plant instrumentation and related electronic measurement and recording devices that are used in the power plant environment. Trouble shoot and repair faulty equipment (at board level) employing dual trace scopes, frequency generators, digital, analog and other bench test equipment. Operate data acquisition systems and program the computers in high and low level languages. Repair and maintenance of the data acquisition system is also required. 1 year experience in above duties required with a minimum BSEE. 40 hrs per week 7:30 AM-4:00PM. \$34,536/yr. Must have proof of legal authority to work permanently in the U.S. Send resume in duplicate (No Calls) to S. Holton, JO#1255676, Ohio Bureau of Employment Services, P.O. Box 1618, Columbus, Ohio 43216.

Help Wanted: Localization Project Engineer. By 5/31/91 Please send resume to: Employment Security Department, ES Division, Attn: Job

#249794-H, Olympia, Washington 98504. Job Description: Designs international product localization specifications for micro computer software and works with software engineers and international testers to implement changes to U.S. designed and produced software that will accommodate product localization for Spanish-speaking markets. Manages localization associates and specialists to localize software for Spanish-speaking market. Works with translators, editors, typesetters, and printers to produce Spanish manuals to accompany software. Communicates with subsidiaries of company in Spain and South America re software needs. Job Requirements: B.A. or B.S. in electrical engineering, computer science, mathematics or physics. Six months work experience in software localization programming for spanish-speaking countries. Must be able to fluently speak, write and read Spanish and English. Must have legal authority to work in the United States. Job location: Redmond, Washington. Salary: \$30,450-\$32,000 per annum, depending on experience. 40 hours per week, flex time. EOE.

Vertical Marketing Managers—Wolfram Research, Inc., developer of Mathematica, seeks professionals to develop marketing programs to effectively penetrate engineering and science markets. Positions entail technical presentations, customer problem solving, and the ability to travel. Qualifications include an advanced degree in respective field and familiarity with technical products like Mathematica. For consideration, send resume to: Wolfram Research, Inc., P.O. Box 6059, Champaign, IL 61826-6059. Affirmative Action/Equal Opportunity Employer.

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Electrical Engineer. 40hrs./wk., overtime N/A; 8:00 a.m.—5:00 p.m., \$36,000/yr., overtime N/A. Duties: research and design on the software development and hardware implementation in the employment of digital signal processing techniques on company electronic communication products which include: line echo cancellation, acoustic echo cancellation, signal compression, voice operated switching and signal routing; responsible for other assigned research projects in the area of digital signal processing. Requirements: bachelor and master degrees in electrical engineering; graduate courses in digital signal processing, adaptive signal processing, random signal processing, and digital system design; experience in the following as evidenced by working or by research: computer language C; digital signal processors and assemblers; frequency domain; and two years of experience in job offered or two years working as an engineer in telecommunications area. Applicants must have proof of legal authority to work permanently in the U.S. Applicants send resumes to: Illinois Department of Employment Security, 401 South State Street—3 South, Chicago, IL 60605, Attention: Len Boksa, Reference #V-IL-1744-B, No Calls. An Employer Paid Ad.

Electrical Engineer wanted. Duties: Conducting analytical studies on engineering proposals to develop designs for automotive components such as electrical harnesses, electrical systems, brackets and other attachment features for electrical wiring and routing of electrical wiring both manually and using the CADAM system. Preparing systems layout and detail drawings and schematics of these components. Studying programmable logical controller systems for their reliability and compatibility to improve existing electrical system for better performance and cost reduction. Requirements. Bachelor's in Electrical Engineering, 2 yrs exp in the job offered or 2 yrs exp as Electrical Engineer, Design Engineer or Designer. All of the related exp must include designing electrical systems for vehicle and vehicle components, including electrical harnesses and engine brackets. One year of the related exp. must include computer aided design of automotive electrical systems using CADAM systems, as

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well as designing programmable logic controls. Pay is \$16 per hour. 40 hr/wk. Resumes to 7310 Woodward Ave., Rm 415, Detroit, MI 48202. Ref. #18191. Employer Paid Ad.

Senior Project Engineer, Grade 8: Requires ■ BS in Electrical Engineering. Will be responsible for resolving technical engineering issues within the electrical module of an electronic reprographic product. (Includes the supervision of a technical support staff of five people.) Will review electronic control systems and failure data of the reprographic product to analyze and prepare base reliability statistics in order to recommend design modifications for improvement of electronic control systems. Must have at least five years' experience as Electronic Design Engineer working with electronic reprographic programs and the preparation of base reliability statistics from analysis of test data. 5 day, 40 hr/wk \$51,700/yr. Reply with resume to: B. Herman, NYS Dept. of Labor, 140 West Main Street, Rochester, New York 14614. Refer to: NY0501464. EOE.

Engineering, Senior Analyst: Materials and failure analysis for advanced FAB processed devices, including imaging, bulk and surface analysis to improve manufacturing and reliability. University research, training or experience with TEM, SEM/EDX/WDX; with data analysis, modeling and simulation; and with thin film deposition, testing and characterization. Ph.D./Mat. Sce./Engr. \$4,195/mo. Job Location: Chandler, AZ. Qualif. applic send resume or applic. letter with ad by May 30, 1991 to: AZ DES Job Services, Attn: 732A Re: 5335838, P.O. Box 6123, Phoenix, AZ 85005. Emp pd ad. Proof of authorization to work in U.S. required if hired.

RF Engineers—Geo-Centers, Inc., ■ high technology, growth-oriented research and development company specializing in engineering and high-tech services for the U.S. Department of Defense, has the following immediate, full-time openings at our central New Jersey location: **Senior RF Engineer**—to perform R&D on high stability frequency standards and clocks, including oscillator design and specifications; and resonator and oscillator testing. A PhD in EE or ■ related field and CAD/ATE experience are desirable. Must be a self-starter who is capable of independent and creative work in an R&D environment. **RF Engineer**—to perform R&D on high stability frequency standards and clocks, including oscillator design, fabrication and specification; and resonator and oscillator testing. A BS in EE or a related field and CAD/ATE experience are desirable. Experience in data analysis, modern computational methods and good oral and written communications skills are necessary. Geo-Centers, Inc. offers competitive salaries, an outstanding benefits package and unlimited growth potential. To explore these positions, please forward your resume with salary requirements to: Geo-Centers, Inc., Human Resources Dept. RF, 762 Rt. 15 South, Lake Hopatcong, NJ 07849. An Equal Opportunity/Affirmative Action Employer. U.S. Citizenship or permanent residency required.

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ing w/microprocessors, microcontrollers & digital signal processors & incl. practical exp. in designing & fabricating servo related electronics. Must possess demonstrated theoretical & analytical understanding of adaptive & repetitive controllers for disturbance rejection on disk drive systems, as evidenced by relevant publication history in scholarly journals. Must possess theoretical & practical understanding of analog, digital & hybrid single-input single-output & multi-input multi-output control systems including non-linear, robust, adaptive, optimal, linear-quadratic gaussian, multi-rate control theory & stochastic estimation techniques for application in control engineering analyses. Must also possess theoretical & practical understanding of dynamics of mechanical systems, incl. modes of vibration, methods for measuring vibrations, & mechanisms that cause vibrations to be coupled from one component to another component. 40 hrs/wk, \$58K/yr. Job site/interview: San Jose, CA. Send ad and resume to Job #JW24042, P.O. Box 9560, Sacramento, CA 95823-0560 no later than May 31, 1991. EOE.

Systems Analyst, Expert and Database System—to design computer systems based on Artificial Intelligence which integrate expert systems with large scale database systems using proprietary software for applications in commercial, scientific, engineering and other complex environments, and provide instruction to customers' staffs in using the systems that have been designed, (Utilizing MVS, VM, VMS, UNIX, and DOS operating systems, FOCUS, COBOL, C, LISP, CLIPS, and OPS5 computer languages,) and requiring extensive and frequent travel. Qualified applicants must have B.Sc. or equivalent degree in Computer Engineering and thorough proficiency in MVS, VM, VMS, UNIX, DOS operating systems, FOCUS, COBOL, C, LISP, CLIPS, and OPS5 computer languages, and the design of computer systems based on Artificial Intelligence and large scale database systems. Salary: \$31,000 per year plus bonus eligibility based on performance and employee benefit plan; 40 hour week. Respondents must presently be eligible for permanent employment in the U.S. Position is with computer service company located in St. Louis County, Missouri. Send resume and details of required proficiencies to: Mrs. Jimmie Gaston, ID# 457675, Missouri Division of Employment Security, 505 Washington Avenue, St. Louis, Missouri 63101. An Equal Opportunity Employer. An Employer Paid Ad.

Regional Director Latin America: Responsible for directing sales/marketing of utility delivery systems/products in Latin American/Caribbean. Responsible for selecting sales channels, developing/implementing sales strategies, managing sales contracts, performing power system studies, providing technical assistance to customers. Experience/familiarity with IEC and ANSI electric standards required. Also required: BSEE with major in power, 6 years electrical engineering experience with 3 of those years on-site in a Latin American or Caribbean country. Fluency in Spanish on a technical level, 1 yr. of marketing/sales experience of ■ technical product. Person must travel 40% of the time, 40 hours/week. 8:30 a.m.—5:00 p.m. daily. \$78,000/yr. Submit resume only to Job Service of Florida, 701 S.W. 27 Avenue Room 16, Miami, Florida 33135. Job order #FL0407735.

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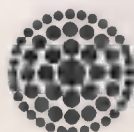
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Scanning The Institute

'Wireless society' gains

A U.S. wireless society advanced on two fronts with the Federal Communications Commission's approval of three applications by cable TV companies for trials of wireless personal communications networks and Motorola Inc.'s introduction of a wireless local-area network for offices [THE INSTITUTE, May/June, p. 1].

First technology R&D awards

The first awards made under the U.S. Commerce Department's Advanced Technology Program went to 11 winning R&D programs. Among the technologies to be studied are improved semiconductor manufacturing techniques, optical recording, several computer hardware and software techniques, high-temperature superconductivity, machine-tool control, and a novel laser design [THE INSTITUTE, May/June, p. 1].

Restoring power a priority in Kuwait

Electric power restoration remains a priority in war-devastated Kuwait, according to a source in the Kuwaiti embassy in London. Telecommunications, computer, and air traffic control systems also were accorded precedence in the technology area. Repair of the Kuwaiti infrastructure will cost up to US \$100 billion over the next five years [THE INSTITUTE, May/June, p. 1].

1991 Medalists announced

Eleven distinguished engineers will receive the 1991 IEEE Medals, and the IEEE will welcome Akio Morita, chairman of the board, Sony Corp., as its newest Honorary Member. The recipients will be presented with their medals on June 16 in San Francisco [THE INSTITUTE, May/June, p. 12].

The parent track

Family and other interests are persuading more and more engineers to scale back their careers, at least temporarily. Some employers are beginning to accommodate this trend by designing flexible work arrangements or letting employees work part time [THE INSTITUTE, May/June, p. 2].

Reactor breeds less waste

An alternative nuclear fuel composed of metal alloy rather than the standard ceramic is being used in an experimental reactor providing 19.5 megawatts of power to southeastern Idaho. Besides being easier to reprocess, the alloy, with 90 percent uranium and 10 percent zirconium, is designed to fuel an integral fast reactor that consumes its own longest-lived wastes [THE INSTITUTE, May/June, p. 6].

Mapping the brain

The National Science Foundation announced plans to grant up to US \$10.6 million to establish a Science and Technology Center that would develop a new generation of magnetic resonance imaging (MRI) technology to map the human brain. The center will be based at the University of Illinois at Urbana-Champaign, home of the father of MRI, Paul C. Lauterbur, who has been named director and principal investigator for the center [THE INSTITUTE, May/June, p. 3].

Coming in Spectrum

ASIAPOWER 2000. Over the past two decades Asia has become a power in technology, with aspirations to challenge Europe and North America. *IEEE Spectrum* examines the anatomy of the region's power, its new economic and geopolitical impact, and its prospects by the end of this century.

One section of this special issue analyzes the "power crescent" of Japan and the "four tigers": South Korea, Taiwan, Hong Kong, and Singapore. Taken together, the trade done by "the tigers" approximately equals that done by Japan, the titan in the region. Evolving economies like those in China, India, and Malaysia—which could become part of a regional trading bloc rivaling Europe's and North America's—also are discussed.

Another section provides a technology status report on the area in nine categories: consumer electronics, ICs and computers, automotive electronics, industrial communications and automation, telecommunications, aerospace and military, medical electronics, power, and transportation.

A third segment presents a sociotechnological profile that assesses how companies and industries compete—in manufacturing, design, R&D, and marketing—through alliances, by attracting cross-national investment, and through government industrial policies and aid. Japan's Ministry of International Trade and Industry and its counterparts in the "little tigers" are profiled, and the role of cultural factors, education, training, and professional societies is described.

A closing segment forecasts trends and directions across the region through the eyes of experts in various companies and technologies. These authorities address such questions as: where the region and key countries are going in technology; in what technology areas chances are best for making a special impact; what breakthroughs are needed and by whom; and what main problems may loom, including intra-regional hostility or shocks related to resources.

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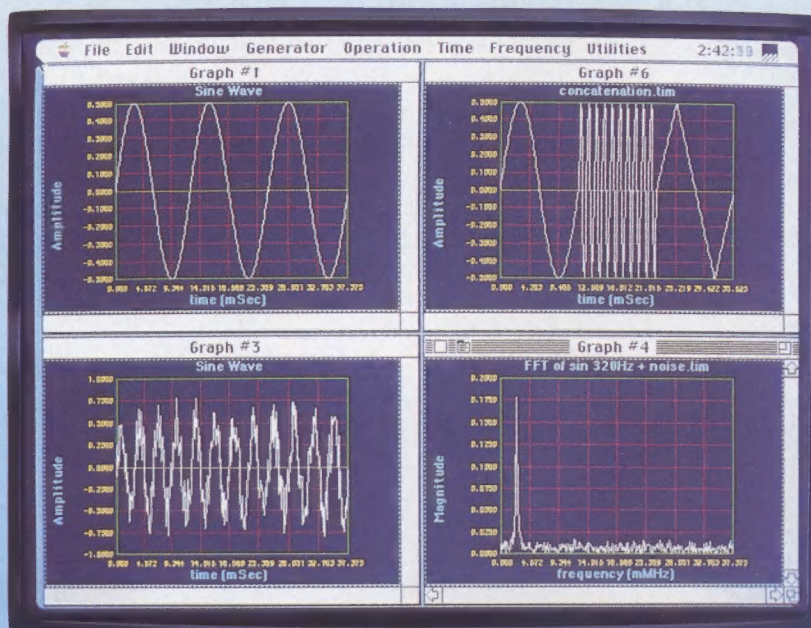
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